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SOLDIER INTEGRATED HEADWEAR SYSTEM: CONCEPTUAL DESIGN PHASE SUMMARY REPORT

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Abstract

The aim of the Soldier's Integrated Headwear System (SIHS) project is to empirically determine the most promising headwear integration concept that significantly enhances the survivability and effectiveness of the future Canadian soldier/warfighter by developing, evaluating, and demonstrating novel concepts for integrating enhanced protection, sensing, information display, and communications technologies into a headwear system. The SIHS design cycle comprises four developmental phases: concept design, digital models, physical mock-ups, and a final functional prototype. This report describes the process and results of the concept development phase.

Seven concept helmet designs were developed using conceptual foci based on helmet and operational functions, and helmet capabilities in relation to the five NATO capability areas: lethality, survivability, mobility, sustainability, and C4I. A downselection process was then undertaken to progress the most successful features and capabilities of the seven concepts into four new concepts for further development in the Digital Model Development phase. The traceability of all design ideas, from the initial seven concepts through to the four new downselected concepts, is detailed in this report.

Résumé

Le but du projet de Casque intégré du soldat (SIHS) est de déterminer empiriquement quel concept de casque intégré est le plus susceptible d'améliorer la capacité de survie et l'efficacité du soldat/combattant canadien de demain, grâce au développement, à l'évaluation et à la mise à l'essai de nouveaux casques qui intègrent une protection accrue, des capteurs, un système d'affichage des informations et des systèmes de communication. Le cycle de développement du SIHS comprend quatre phases : élaboration de concepts, développement de modèles numériques, production d'une maquette, et production d'un prototype fonctionnel. Le rapport décrit le processus de développement et les résultats de la phase d'élaboration de concepts.

Sept concepts de casque intégré ont été développés en mettant l'accent sur le casque et ses fonctions opérationnelles, et sur la performance par rapport aux cinq domaines de capacité de l'OTAN : létalité, survivabilité, mobilité, soutenabilité et C4I. Un processus de sélection des meilleures idées a ensuite été entrepris pour ramener de sept à quatre le nombre de concepts retenus pour la phase de développement de modèles numériques. Tous les nouveaux concepts, depuis les sept concepts initiaux jusqu'aux quatre concepts sélectionnés, sont décrits dans le rapport.

Executive Summary

The aim of the Soldier's Integrated Headwear System (SIHS) project is to empirically determine the most promising headwear integration concept that significantly enhances the survivability and effectiveness of the future Canadian soldier/warfighter by developing, evaluating, and demonstrating novel concepts for integrating enhanced protection, sensing, information display, and communications technologies into a headwear system.

The SIHS design cycle comprises four developmental phases: concept design, digital models, physical mock-ups, and a final functional prototype. This report describes the process and results of the concept development phase.

The first step in the conceptual design process was to establish a framework that could be used to focus brainstorming efforts across a range of conceptually diverse options. The framework included the development of capability matrices for helmet functions, operational functions, and helmet capabilities, and these were related to the five NATO capability areas: lethality, survivability, mobility, sustainability, and C4I. These conceptual foci were then used to develop seven concept helmet designs.

A downselection process was then undertaken to progress the most successful features and capabilities of the seven concepts into four new concepts for further development in the Digital Model Development phase. The aim of the downselection process was not to simply accept or reject the initial seven concepts, but rather to retain the best ideas from those concepts and advance those ideas to the Digital Model phase of the project. The downselection approach consisted of a review of the initial concept designs by the SIHS sub-system teams, and engineering and human factors assessments by the industrial team. Based on the results of this downselection process, and the addition of new design ideas, four new helmet concepts were developed.

For these four new designs, the fidelity of the concept images was improved to better represent the scale of the helmets and their components. Digital scale models were created for available helmet components including visual sensors and displays, respiratory equipment and sample helmet shells. A digital headform model, representing an average medium-sized Canadian soldier's head was also used to scale the new concept images to improve the realism of the design concept drawings.

The traceability of all design ideas, from the initial seven concepts through to the four new downselected concepts, is detailed in this report.

Sommaire

Le but du projet de Casque intégré du soldat (SIHS) est de déterminer empiriquement quel concept de casque intégré est le plus susceptible d'améliorer la capacité de survie et l'efficacité du soldat/combattant canadien de demain, grâce au développement, à l'évaluation et à la mise à l'essai de nouveaux casques qui intègrent une protection accrue, des capteurs, un système d'affichage des informations et des systèmes de communication.

Le cycle de développement du SIHS comprend quatre phases : élaboration de concepts, développement de modèles numériques, production d'une maquette, et production d'un prototype fonctionnel. Le rapport décrit le processus de développement et les résultats de la phase d'élaboration de concepts.

La première étape du processus d'élaboration de concepts a été l'établissement d'un cadre pour concentrer les efforts de développement sur un certain nombre d'options. Ce cadre prévoyait notamment l'élaboration de matrices de capacités pour le casque proprement dit, les fonctions opérationnelles, et la performance par rapport aux cinq domaines de capacité de l'OTAN : létalité, survivabilité, mobilité, soutenabilité et C4I. Ce cadre a permis d'élaborer sept concepts de casque intégré.

Un processus de sélection des meilleures idées a ensuite été entrepris pour ramener de sept à quatre le nombre de concepts retenus pour la phase de développement de modèles numériques. Le but du processus de sélection n'était pas simplement d'accepter ou de rejeter les sept concepts initiaux, mais de retenir les meilleures idées liées à ces concepts pour la deuxième phase du projet : le développement de modèles numériques. Dans le cadre du processus de sélection, les équipes chargées des divers sous-systèmes du SIHS ont examiné les concepts initiaux, et l'équipe industrielle a examiné les facteurs techniques et humains. À partir des résultats de ce processus de sélection et des autres idées nouvelles qui ont été proposées, quatre concepts de casque intégré ont été élaborés.

Pour ces quatre nouveaux concepts, la fidélité de l'image a été améliorée afin de mieux représenter les dimensions des casques et leurs éléments. Des modèles numériques à l'échelle ont été produits pour les divers éléments, y compris les capteurs optiques, les systèmes d'affichage, les équipements respiratoires et les enveloppes des casques. Un modèle numérique représentant la tête d'un soldat canadien de taille moyenne a également été utilisé pour améliorer le réalisme de la représentation graphique des nouveaux concepts.

Tous les nouveaux concepts, depuis les sept concepts initiaux jusqu'aux quatre concepts sélectionnés, sont décrits dans le rapport.

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1 Introduction

This report presents the results of the conceptual design phase of the Soldier's Integrated Headwear System (SIHS) project. The following section provides background to the project and the design phases, outlines the SIHS team, and describes the purpose and structure of the document.

1.1 SIHS Design Project

The aim of the SIHS project is to empirically determine the most promising headwear integration concept that significantly enhances the survivability and effectiveness of the future Canadian soldier/warfighter by developing, evaluating, and demonstrating novel concepts for integrating enhanced protection, sensing, information display, and communications technologies into a headwear system.

Figure 1 outlines a general model of the SIHS design process. The model comprises three major activities: system definition, the design cycle, and an evaluation process. While the process began with system definition activities, all three major activities are interactive, iterative, and ongoing throughout the life of the design process.

> **System Definition:** The system definition activity defined and delimited the design problem space to gain a better understanding of the design options available to achieve the design goals.
>
> **Design Cycle:** The design cycle employs the insights derived in system definition to guide the initial concept development activities. The insight acquired in the design cycle will also stimulate the need for additions, deletions, and modifications to the system definition activities.
>
> The SIHS design process seeks to determine a wide range of conceptually different integrated headwear system design ideas. As the SIHS programme progresses, these concept ideas will be modeled and evaluated in a process of iterative downselection from conceptual drawing to functional prototypes.
>
> **Evaluation Process:** An evaluation process of trade-off analyses, research, and development testing will be ongoing at each stage of design to assess the effectiveness of alternative technologies, sub-system integration, and system integration.

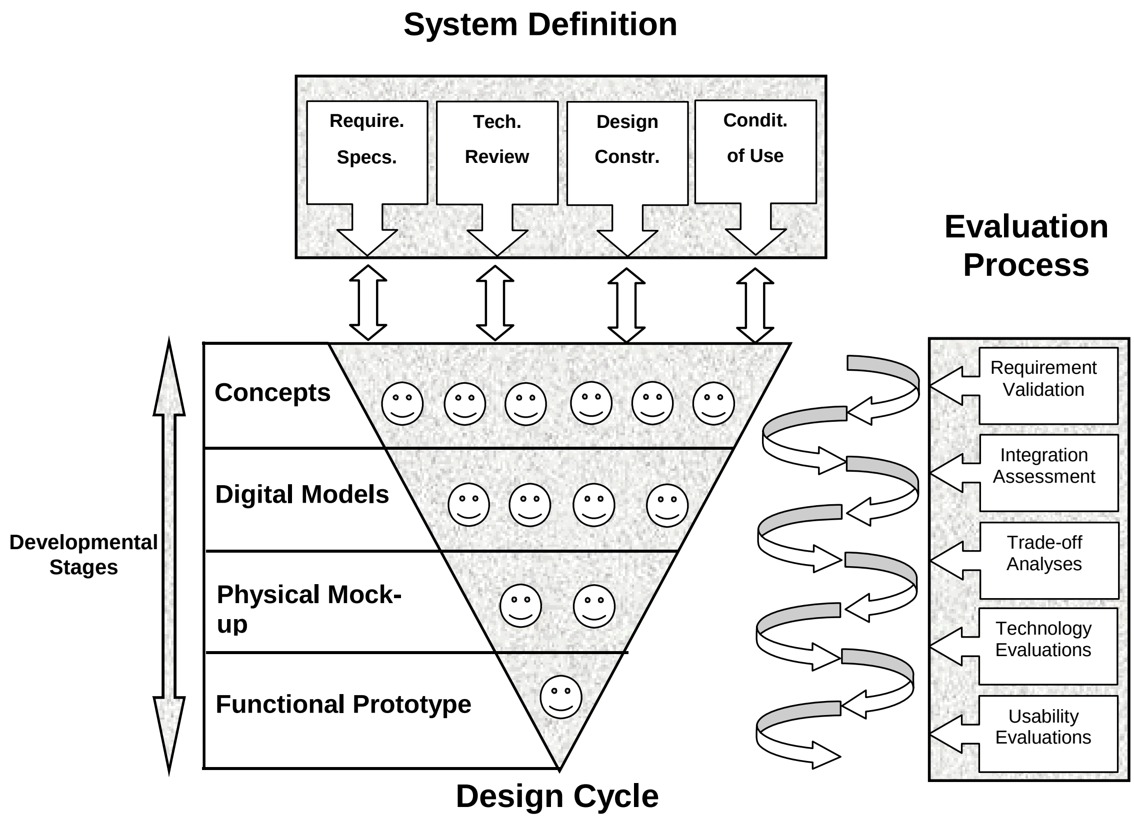


Figure 1: SIHS Process

1.2 Developmental Design Phases

The design cycle comprises four developmental phases: concept design, digital models, physical mock-ups, and a final functional prototype. The steps in the evaluation process are applied to each phase in an iterative manner to develop, define, and discard design attributes.

Concept Development Phase: Concepts are an abstraction of generalized ideas borne out of creative brainstorming. These concepts do not necessarily need to be conceived in great detail or even practically achievable at this stage. In the case of concept development, judgement is somewhat suspended in favour of creativity until imagination and ingenuity have been exhausted. At this point the design concepts can then begin to be challenged by the evaluation process. This report describes the process and results of the concept development phase.

Digital Model Development Phase: Digital Models are used to further define and refine a shape model for these concept designs (e.g. CADD). Digital models enable a rapid prototyping environment for the preliminary assessment of design integration, accommodation, compatibility, fit, thermal demands, visual field, etc.

Physical Model Development Phase: Physical mock-ups provide a space and weight representation of the concept and provide the capability for the physical integration of componentry. Mock-ups are also necessary for initiating soldier-in-the-loop design testing and evaluation.

Function Model Development Phase: Functional prototypes include working componentry and hardware. While the functional prototypes must represent the finished product to a high fidelity not all aspects need to be "real". To save cost and time some aspects can be simulated for the purpose of human factors evaluations. For example, the helmet shell does not require high performance ballistic materials when a cheaper material could be used to simulate the space and weight effects of the shell.

These developmental stages progress a conceptual idea to a working model but not all concept types will necessarily be developed to a fully functional prototype. Depending on the results of the evaluation process for any given concept type it is possible that the project could decide to cease development at a particular stage. The project may be satisfied with the knowledge acquired for a concept type by a particular stage, or the concept type might be proving unsuccessful, or the project may elect to be opportunistic by diverting resources to another concept type that is proving to be more successful.

1.3 The SIHS Team

Each SIHS design phase has the active involvement of the entire SIHS team. The SIHS team is multi-disciplinary and comprises membership from an industrial team (Humansystems Incorporated, Oerlikon Contraves, Mine Safety Appliances, Heatherington Welch Design, and Biokinetics), and defense scientist teams and a Project Management Office (PMO) from Defence Research and Development Canada (DRDC), as well as representatives from both the user requirments and engineering or procurement directorates of NDHQ.

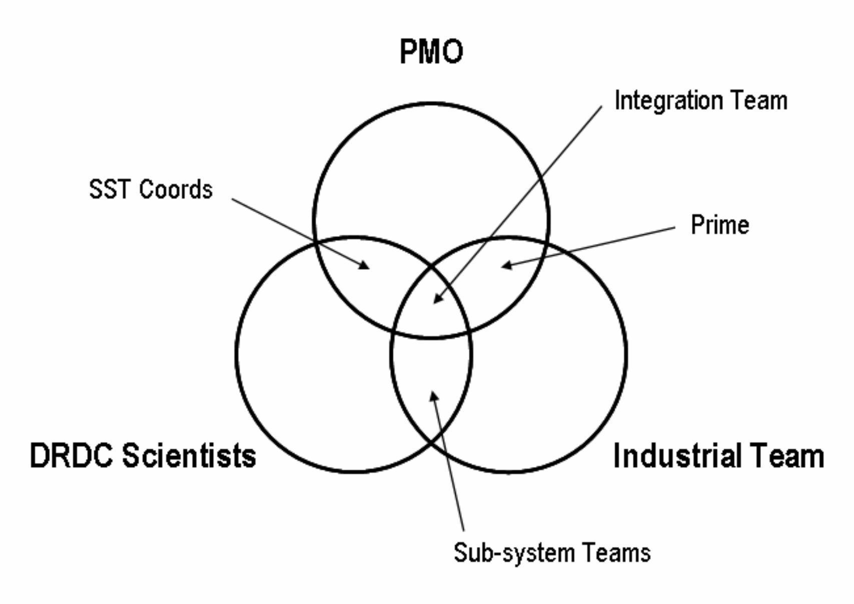


Figure 2: SIHS Team Organization

Figure 2 illustrates the SIHS team membership and relationships. The Industrial team progresses the SIHS design and undertakes design studies. Sub-System Teams (SST) provide specialist advice on design issues and resolve knowledge gaps to support design decisions. SSTs are organized with defence scientists, specialists from government and the industrial team, and Subject Matter Experts (SME) from the operational community. The four SST teams include the Head/Shell team, the Vision team, the Speech/Comms team, and the Respiratory team.

Key members of the PMO, the SSTs, the industrial team, and the Integrated Soldier System Platform (ISSP) sponsor are organized into the Integration Team to oversee the overall design effort.

1.4 Purpose of this document

This document describes the activities in the design cycle and evaluation process leading to the development of seven initial concept designs and their subsequent downselection into four new designs that will continue to be developed in the Digital Model Development phase of the SIHS project.

1.5 Document Outline

This document is organized into the following chapters.

Chapter 1: Introduction

Chapter 1 describes the SIHS project, outlines the design process, describes the developmental design phases involved and introduces the SIHS team.

Chapter 2: Conceptual Design Process

Chapter 2 describes the process used to create a framework for developing the SIHS conceptual designs and details the conceptual foci used to ensure design diverisity.

Chapter 3: Conceptual Designs

Chapter 3 provides sketches and feature/capability descriptions for each of the seven initial SIHS concept designs.

Chapter 4: Feature and Capability Downselection

Chapter 4 describes the goals for downselection, the process used to evaluate these seven concept designs, and the results of the reviews of these designs.

Chapter 5: New Designs

Chapter 5 provides colour drawings and descriptions of the four new SIHS designs and outlines the feature/capability traceability from the initial seven to the four new designs.

Chapter 6: The Next Phase

Chapter 6 outlines the steps involved in the following Digital Model Development phase.

2 Conceptual Design Process

This section explains the process used to develop the initial SIHS helmet concepts. The first step in the conceptual design process was to establish a framework that could be used to focus the brainstorming effort across a range of conceptually diverse options. To develop the framework for creating these conceptual foci the SIHS team considered the following three aspects:

1. Helmet Functions;
2. Operational Functions and Helmet Capabilities;
3. NATO Capability Areas.

Each of these aspects, and the resulting framework, is described in more detail in the following section.

2.1 Helmet functions

Helmet functions were categorized according to five functional areas of the head as shown in Figure 3: head, vision, speech, hearing and respiratory.

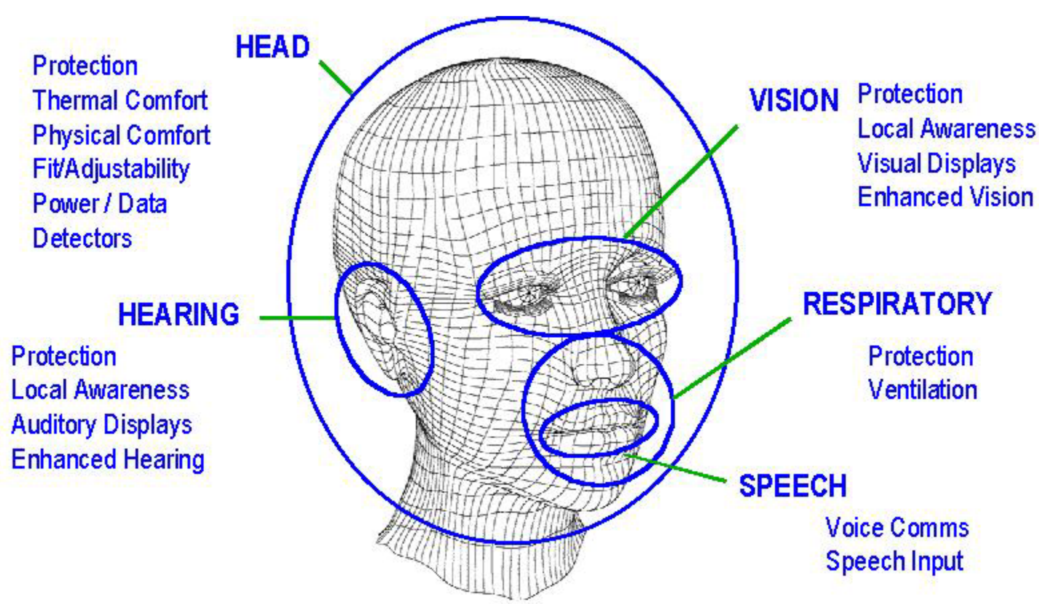


Figure 3: Helmet Functions

A brainstorming session was undertaken to determine the helmet capabilities for each of these five areas and to identify the likely range of technology items available to the design process. The results of the brainstorming session can be found in the mind map diagram in Annex A.

2.2 Operational Functions and Helmet Capabilities

The Canadian Forces have identified five Operational Functions required to achieve future army capabilities: Command, Sense, Shield, Sustain and Act. Based on the five functional areas of the head, helmet technologies and capabilities were identified and assigned to these five operational functions. The five Operational Functions and their associated helmet functions are shown in Figure 4.

Command	Sense	Shield	Sustain	Act
Visual Display sub-system	Free-field Vision	Ballistic	Feeding	Physical Properties
Audio Display sub-system	Free-field Hearing	Blast	Hydrating	Size
Tactile Display sub-system	Enhanced Vision	Chemical	Physical Comfort	Shape
Communications Display	Enhanced Hearing	Biological	Thermal Management	Compatibility
Speech Input Display	Laser Sensors	Nuclear	Physiological Monitoring	Modularity
	NBC Sensors	NBC Sensors		
	Physiological Sensors	Hearing		
	Auditory/Sniper Detection	Vision		
	GPS Antenna	Camouflage		
	RF Antenna			

Figure 4: Operational Functions and Helmet Capabilities

2.3 NATO Capabilities

NATO (North Atlantic Treaty Organization) identifies five capability areas for future soldier system development: lethality, mobility, survivability, sustainability, and C4I. These capabilities are itemized in Figure 5 and provide a framework for organizing the operational functions and helmet capabilities.

Lethality	Mobility	Survivability	Sustainability	C4I
To incapacitate or destroy the enemy To observe and detect events on the battlefield To recognize possible targets To identify and classify targets To relay and receive information on targets To acquire target To engage target To evaluate results of engagement	To move in all environments, day and night To move mounted or dismounted To navigate To receive and provide terrain information To traverse terrain on foot To overcome obstacles To carry loads on the move	To survive threats, natural or man-made To avoid detection by the enemy To deceive the enemy To detect threats To receive and transmit information on threats To prepare defensive positions To protect against ballistic, DEW, blast, and NBC To provide information on terrain and weather To preserve human capabilities in all weather	To support physiological/physical functions To support a soldier's fighting capability To support equipment requirements To monitor health To administer medical aid (including NBC) To include embedded training To minimize the effects of stress	To receive information visually, verbally and through sensors To process information To store information To present information To distribute information

Figure 5: NATO capabilities

2.4 Conceptual Foci Framework

The matrix in Figure 6 indicates the extent to which each helmet function, for each operational function, would contribute towards fulfilling each of the five NATO capability areas. The contribution of each helmet function was rated on a scale of 1 (low contribution) to 5 (high contribution) by members of the industrial team. Items that were not rated for a certain NATO capability were viewed as having no contribution to that capability.

		NATO Functions				
Operational Functions	**Helmet Functions**	**Lethality**	**Mobility**	**Survivability**	**Sustainability**	**C4I**
COMMAND	Visual display sub-system	5	5	3		5
	Audio display sub-system	3	2	3		5
	Tactile display sub-system	2	2	3		3
	Communications display	2		1	1	5
	Speech input device	2		1	1	5
SENSE	Free-field vision	5	5	5		5
	Free-field hearing	4	3	5		5
	Enhanced hearing	4	3	4		5
	Enhanced vision	5	5	5		5
	Laser sensors			4		
	NBC sensors			4		
	Physiological sensors			4	4	
	Auditory/Sniper detection	2		3		2
	GPS antenna	1	4	1	1	5
	RF antenna	1		1	1	5
SHIELD	Ballistic			5		
	Blast			5		
	Chemical			5		
	Biological			5		
	Nuclear			5		
	Hearing			5		
	Vision			5		
	Camouflage			5		
SUSTAIN	Feeding		1		5	
	Hydrating		2		5	
	Physical comfort		4		3	
	Thermal management		4	4		
	Physiological monitoring			4	4	2
ACT	Physical properties	4	5			
	Size	4	4			
	Shape	3	3			
	Compatibility	5	4			
	Modularity	2	4			2

Figure 6: Conceptual Foci Matrix

Using such a matrix, the conceptual design effort could then focus on particular helmet functions in order to emphasize one NATO capability over the others. This focus provided a means for achieving the desired design diversity across several different SIHS concepts.

While it would have been possible to develop a SIHS concept for each of the five NATO capability areas, it was decided that we could achieve more design options and greater design complexity by pairing select capability areas.

Using the matrix as a framework, all possible capability pairing where investigated and the most promising seven foci pairings were selected for conceptual brainstorming. Design concepts were created for the following pairings:

- Concept 1: Mobility / Lethality
- Concept 2: Mobility / Survivability (ballistic)
- Concept 3: C4I (information) / Survivability (CB)
- Concept 4: Survivability (CB) / Mobility
- Concept 5: Survivability (CB) / Survivability (ballistic)
- Concept 6: C4I (Sensors) / Survivability (ballistic)
- Concept 7: Sustainability / Mobility

These seven concepts are presented and described in the following section.

3 Conceptual Designs

The seven initial concept helmet designs are shown and described in this section. Tables detailing the design features and capabilities of each concept are included in Annex B. A summary table detailing the CB mode for each concept is included in Annex C.

3.1 Concept 1: Mobility/Lethality

Concept 1 has the primary focus of mobility and a secondary focus of lethality. This helmet can be mission-configured and scalable for both functionality and protection. Concept 1 is designed as an urban assault helmet that could be up-armoured for different threats. A sketch of Concept 1 is shown in Figure 7.

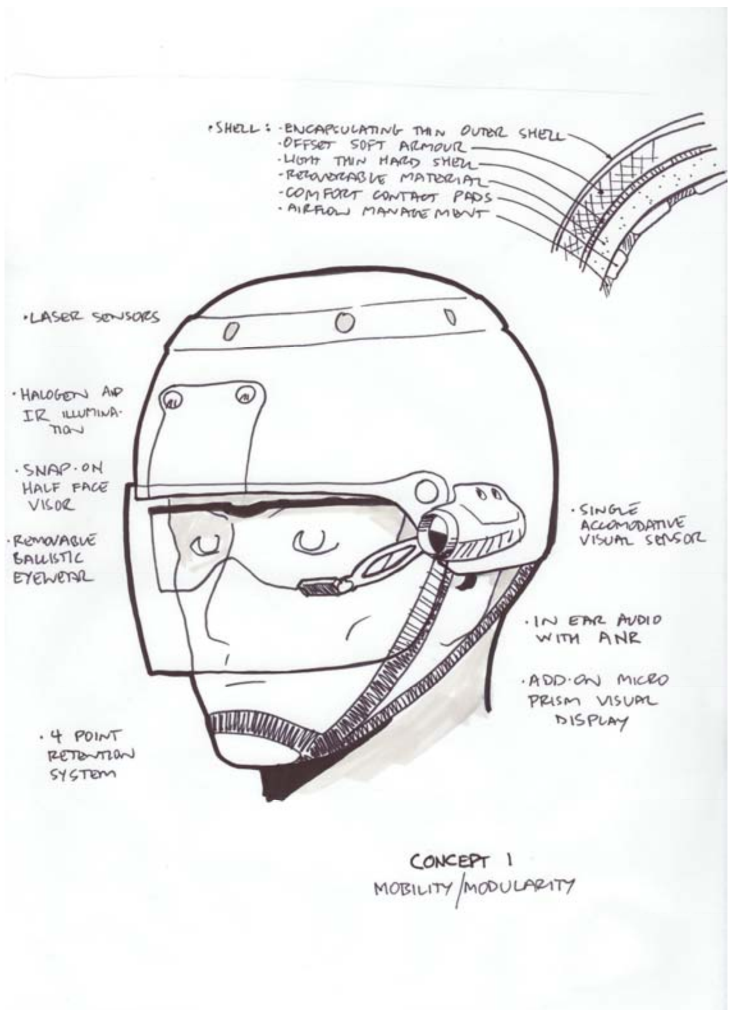


Figure 7: Concept 1 Mobility/Lethality

Key features of the design include a two-layer ballistic shell; the first layer is a bump layer with moderate fragmentation protection, the second layer is soft armour with a flexible lattice offset for higher fragmentation threats. The essential benefit of using a soft armour outer shell is a projected reduction of about 200 grams in overall weight.

To maintain the mission-configurable nature of the helmet, ballistic eye-wear and visors, chemical/biological (CB) protection and visual displays are all add-on components. Audio display and protection is accomplished with an in-ear device providing protection (active noise reduction, active impulse protection), transparent hearing, and an integrated microphone for speech input. The visual display includes a microprism display device. An interchangable enhanced vision sensor is mounted at the side of the helmet where the connector can accept a day camera, night vision sensor, or thermal sensor. CB protection is provided by a standard mask with head harness over a semi-permeable balaclava hood.

3.2 Concept 2: Mobility/Survivability (ballistic)

Concept 2 focuses on a high mobility helmet that can be mission-configured for mobility like Concept 1 but also includes higher ballistic protection and greater protective coverage of the head and neck. Concept 2 is shown below in Figure 8.

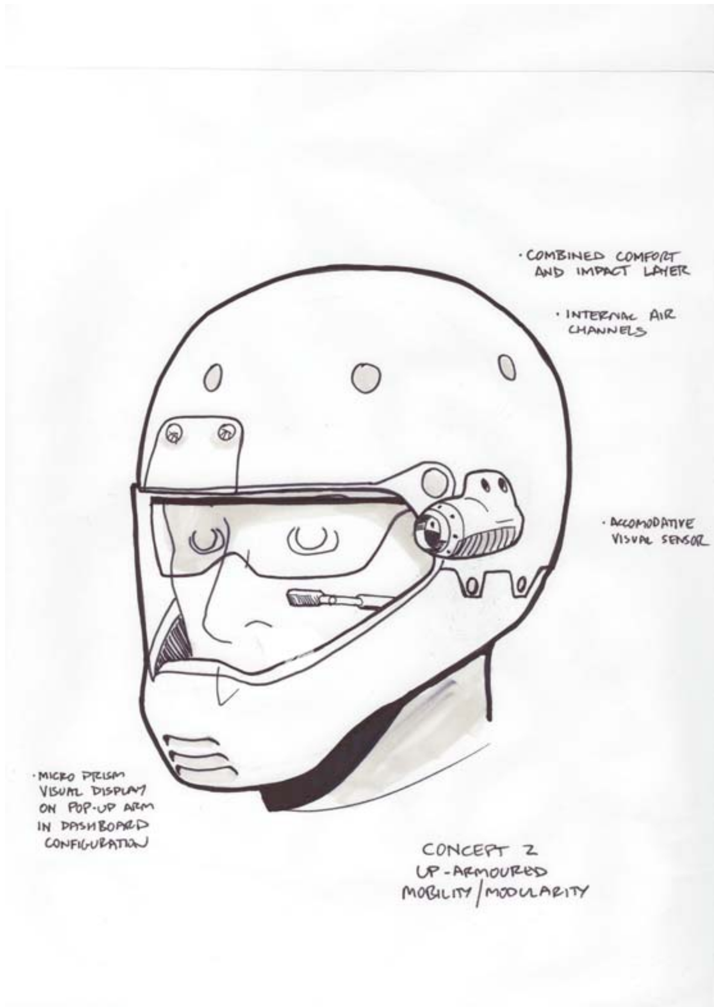


Figure 8: Concept 2 - Mobility/Survivability

Concept 2 provides a higher level of ballistic protection than Concept 1 by using three add-on armour layers. The first layer of protection is a hard shell intended to provide bump protection and moderate protection against fragmentation and penetration. The second layer is a soft armour layer with a flexible lattice offset to provide protection against higher fragmentation threats. The third layer is a hard armour cap to protect against high velocity threats. This design also features a removable mandibular guard for added protection to the neck, face, and jaw.

The visual display is provided as a microprism device in a dashboard configuration and auditory display is provided with an in-ear device. An interchangable enhanced vision sensor is mounted at the side of the helmet where the connector can accept a day camera, night vision sensor, or thermal sensor. White light and IR illumination devices are mounted above the brim of the helmet. CB protection is similar to Concept 1.

3.3 Concept 3: C4I/Survivability

Concept 3 focuses on a helmet with significant display and sensor capabilities (Figure 9). A version demonstrating Concept 3 in a CB protected configuration is shown in Figure 10.

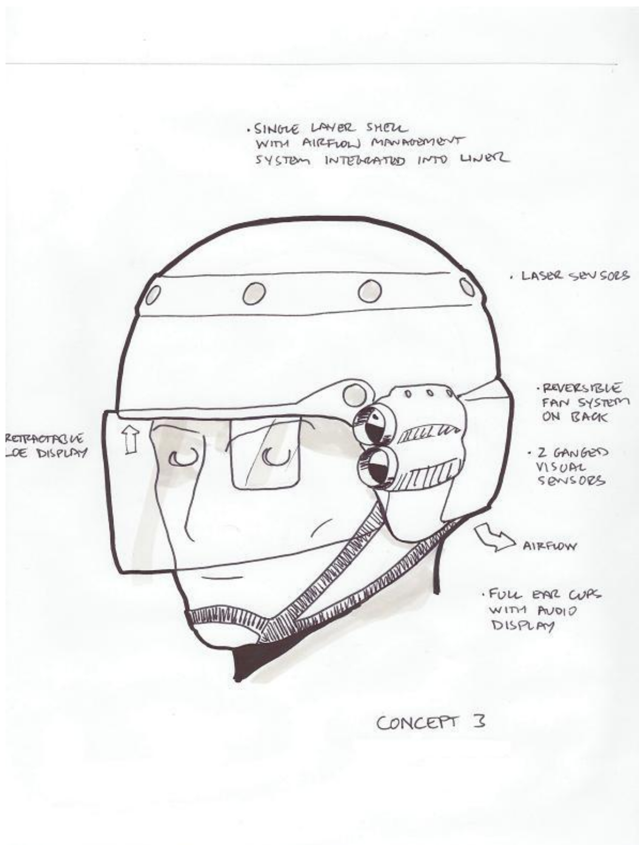


Figure 9: Concept 3 - C4I/Survivability

Concept 3 comprises an augmented reality display (e.g. Light-guide Optical Element (LOE) or Virtual Retinal Display (VRD)) that can be retracted into the shell structure of the helmet at the brow. It features a fully spacialized 3D audio display into earcups that are integrated into the shell at the sides of the helmet. The integrated 3D audio system can be used both to localize environmental sound sources and to spatially separate communications sources. Audio protection is active, and transparent hearing is accomplished with a microphone array of sensors on the helmet exterior. Voice input to the communications system uses a beam-formed microphone array built into the helmet brim.

Two interchangeable visual sensors are grouped at the left ear near the eyeline. The sensors can be either day video, I^2 or IR cameras. Fusion options for I^2/IR or day/IR cameras are also possible. An on-helmet laser array provides directionality to any laser source striking the helmet, which is then related to the wearer's head position to estimate the location of the source.

Figure 10: Concept 3 - CB Mode

The single layer ballistic shell provides coverage below the ears and includes integral airflow channeling with powered airflow to cool the head and defog the visor. The CB solution includes an integrated mask with mono lens, two stackable canisters on the sides of the face, and a powered nape filter. The design of the system enables the wearer to attach the mask without removing their helmet and the mask can be secured using a ratchet system. Airflow filtering involves two stages; the first filtering occurs at the nape filter and provides clean air suitable for cutaneous protection for cooling the head. This first-pass air would then be scrubbed a second time by porting this airflow to the canisters on the mask so that the air filtration was suitable for respiratory protection.

3.4 Concept 4: Survivability (CB)/Mobility

This concept focuses on a CB protective helmet that emphasizes high mobility operations and CB survivability. It is designed to be light with low load forces on the head, low breathing resistance and less heat build-up than other helmets. Concept sketches are shown in Figures 11, 12 and 13.

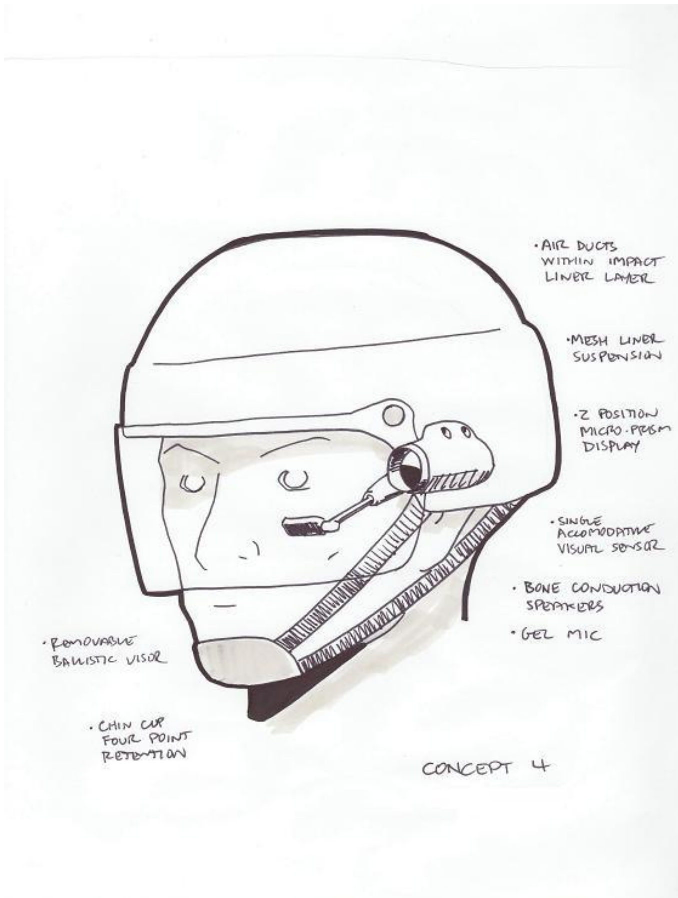


Figure 11: Concept 4 - Survivability (CB)/Mobility

In the non-CB mode, Concept 4 comprises a single layer ballistic shell cut to the mid-line of the ear, with a snap-on ballistic visor (Figure 11). The visual display includes a microprism device and auditory information is displayed through bone conduction transducers. Speech input is achieved with a gel microphone embedded in the helmet liner. An interchangable enhanced vision sensor is mounted at the side of the helmet where the connector can accept a day camera, night vision sensor, or thermal sensor.

In the CB mode Concept 4 features a fully-integrated CB protection system, using a face piece mask that mates to a balaclava seal around the face and below the lips. A ratchet strap system is used to pull the mask into the face using a ratchet knob at the back of the helmet with safety lockouts. Air filtration is achieved using a filter blower system mounted to the torso providing clean air through a hose feed to the back of the helmet to provide cooling air, better protection and less weight on the head. Airflow channels travel from the front of the helmet and converge at the hose opening. The face piece mask seals in front of these channel outlets. This concept uses a double canister system, with hot-swappable canisters on the torso blower and a service-life indicator built into each mask with an audio display to indicate when to change out canisters. There are no canisters on the mask or head. As a low-power option, a canister can be attached directly to the hose opening at the back of the helmet.

Examples of the CB mode concept are provided in Figures 12 and 13.

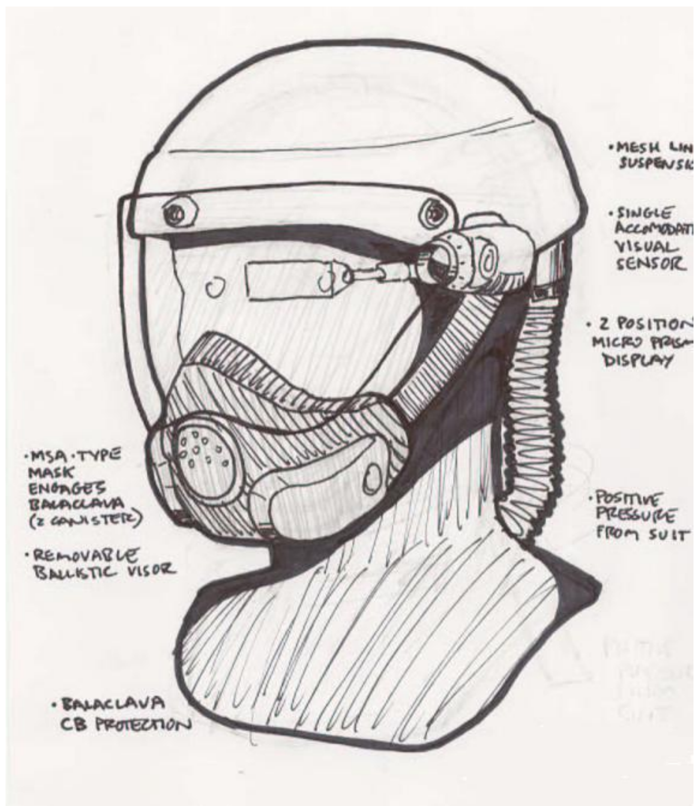


Figure 12: Concept 4 with CB Version 1

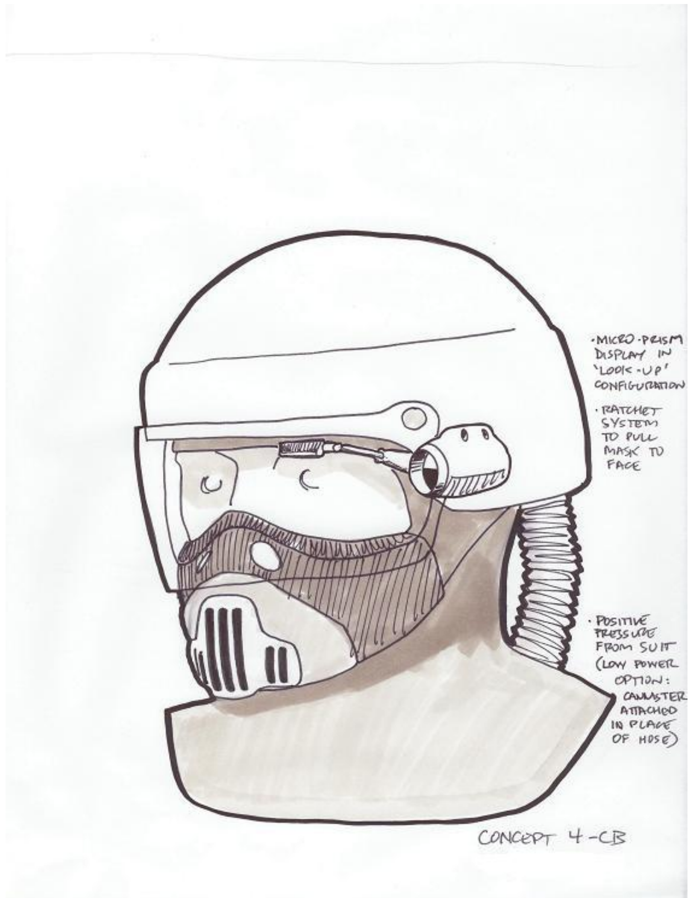


Figure 13: Concept 4 with CB version 2

3.5 Concept 5: Protection (CB)/Protection (ballistic)

Concept 5 focuses on a highly protective helmet for both CB and ballistic threats. Concept sketches are shown in Figures 14 and 15.

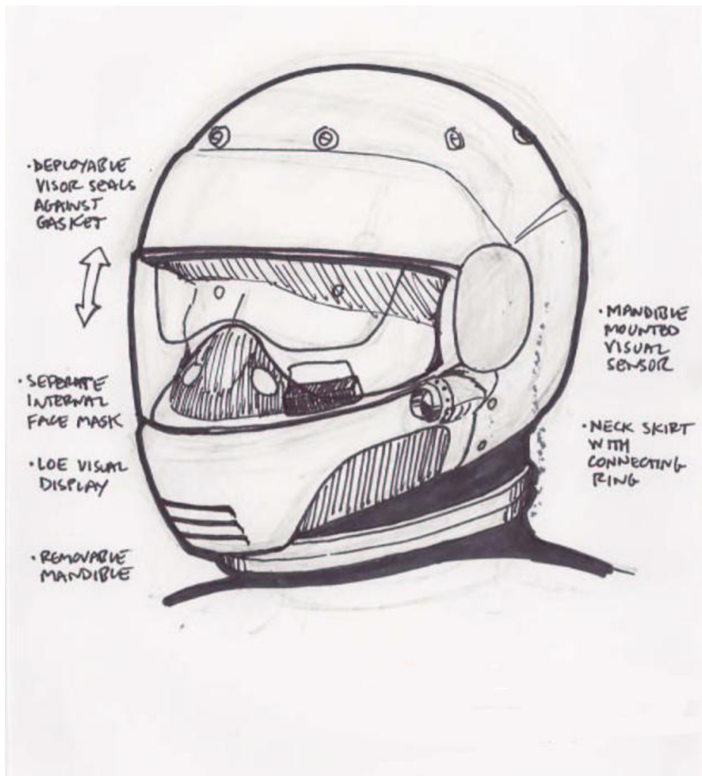


Figure 14: Concept 5, Protection (CB)/Protection (ballistic) - Version 1

Concept 5 is a high coverage one-piece ballistic helmet with a detachable mandibular guard. High levels of impact protection are provided by a crushable foam liner and a 3D weave comfort layer to improve ventilating airflow. A webbing/leather headband suspension is used to improve backface deformation and ventilation. Ballistic eyewear is retractable up under the helmet brim and the ballistic visor is deployable out over the shell. The visual display includes retractable biocular LOE displays and the auditory display includes 3D audio capabilities in an integrated ear cup. Speech input is achieved through a beam-formed array of microphones in the brim of the helmet. The enhanced vision sensor can be fixed or interchangable for a range of day vision, night vision, and thermal sensors. Enhanced audio includes an array of microphones around the perimeter of the helmet for transparent hearing.

Concept 5 features a CB system integrated into a mandibular guard. The mandible is secured to the helmet and the oronasal cup is pushed into the face using a ratchet screw at the front of the mandibular guard. The mandible includes attachment points for canisters and the oronasal cup. Service-life indicator LEDs are mounted into the mandibular dashboard. A deployable ring can be pulled down from the base of the helmet to connect to a dickie with a mating ring at the CB-Plus torso. Non-structural components of the liner and the oronasal mask comprise a semi-permeable nano-composite material (e.g. poly-vinyl alcohol) suspended on a skeletal framework to reduce weight and heat build-up. The deployable visor can be rotated into place and pulled in to a rubber gasket on the mandible to create a seal.

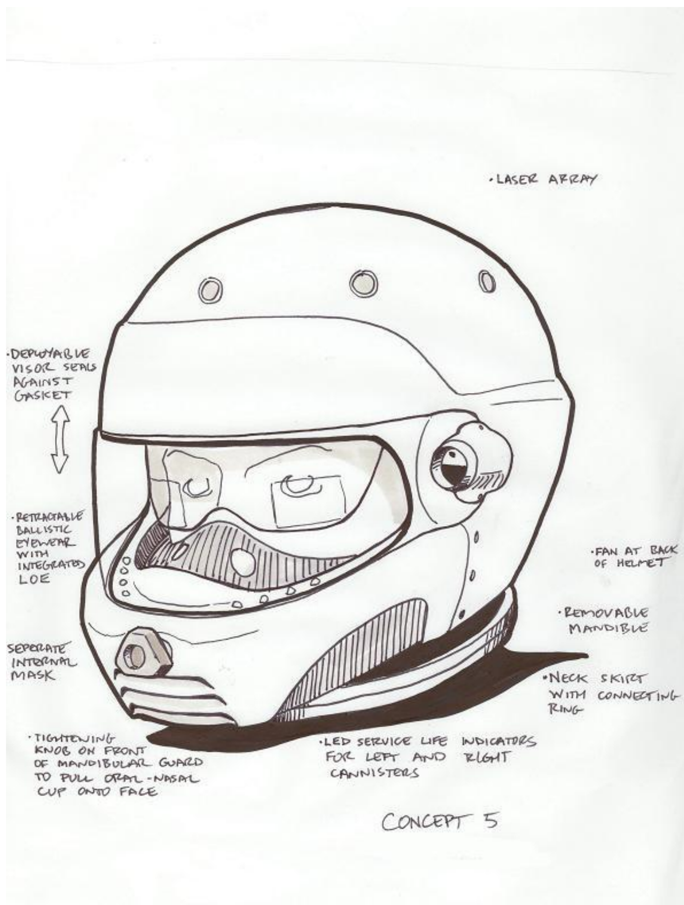


Figure 15: Concept 5, Version 2

CB protection is further enhanced through a positive pressure system using a fan at the back of the helmet. The canisters use monolithic carbon tube technology and are mounted into the mandible for connection to the oronasal cup. The monolithic carbon technology greatly reduces the airway resistance normally associated with filter breathing. This system also employs a double-scrub procedure, using partially filtered air over the head and a second scrub of helmet air through the oronasal canister and over the eyes. The use of a double-scrub technology seeks to increase the service duration of each of the monolithic carbon canisters or could enable smaller lighter canisters on the mandible.

3.6 Concept 6: C41 Sensors/Survivability (high velocity threats)

Concept 6 focuses on an optimized surveillance and information display helmet with a high velocity ballistic up-armour option. It is intended for use in surveillance, reconnaissance and OP missions.

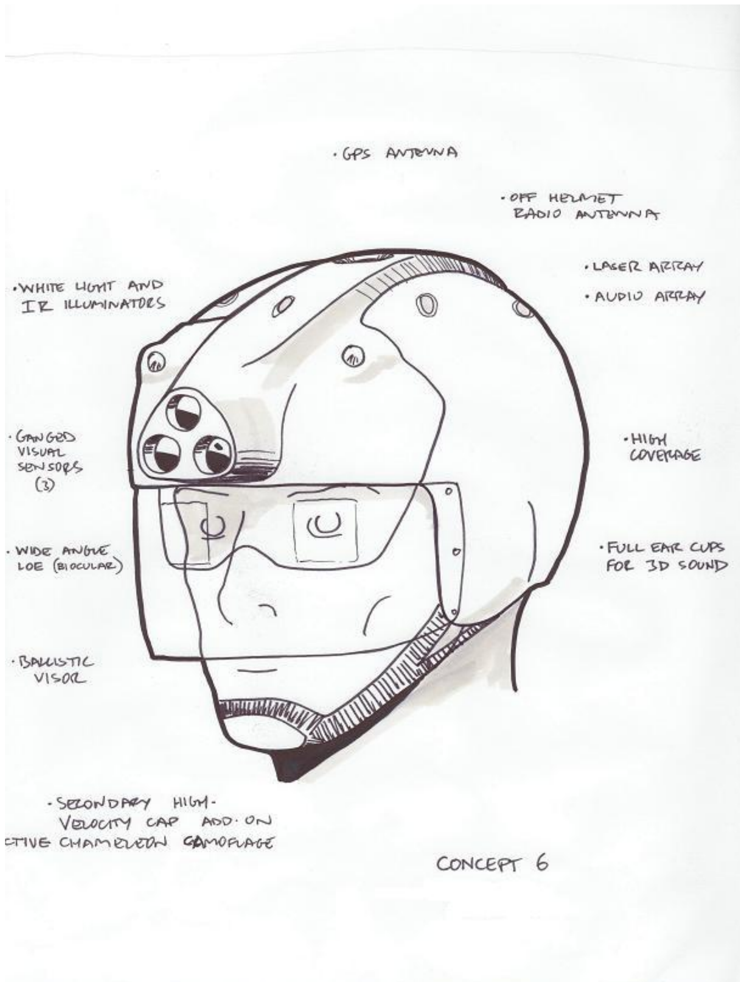


Figure 16: Concept 6 – C41 Sensors/Survivability

Concept 6 includes a one-piece ballistic shell with an add-on high velocity threat protection cap. Ballistic eyewear is retractable into the helmet brim and the ballistic visor is an add-on component. In the non-CB mode (Figure 16) ventilation for cooling the head and defogging the eyewear and visor is provided by an active fan at the back of the helmet.

Biocular LOE visual displays are integrated into the eyewear, which retract with the eyewear. Concept 6 features fully spacialized 3D audio through earcups integrated into the shell of the helmet. The integrated 3D audio system can be used both to localize environmental sound sources and to spatially separate various communications sources. Audio protection includes active continuous and impulse noise protection. A microphone array on the helmet exterior is used to achieve transparent hearing, supernormal hearing, and aural focussing to attend to sounds in a particular location. Voice input to the communications system is achieved via a beam-formed microphone array built into the helmet brim.

Three visual sensors (day, I^2 and IR) are grouped together on the forehead area of the helmet. White light and IR illuminators are co-located beside the visual sensor suite. A fixed array of micro-cameras is included to record surrounding terrain for chameleon camouflage. A six-sensor laser array is used for determining the direction of a scanning laser source.

Figure 17: Concept 6 – CB mode

In the CB mode (Figure 17), Concept 6 features a CB-protection system fully integrated into a mandibular guard with an oronasal cup and a deployable ring at the base of the helmet. The deployable ring pulls a tensioned neck gaiter down to overlap over a semi-permeable CB protective dickie covering the shoulders and neck. Two canisters are attached to the mandible ring at the nape of the helmet, and a reversible fan at the back of the helmet provides positive pressure.

3.7 Concept 7: Sustainability/Mobility

Concept 7 focuses on prolonged wear, physical and thermal comfort and low power consumption for use in unsupported missions such as long range patrols (Figure 18).

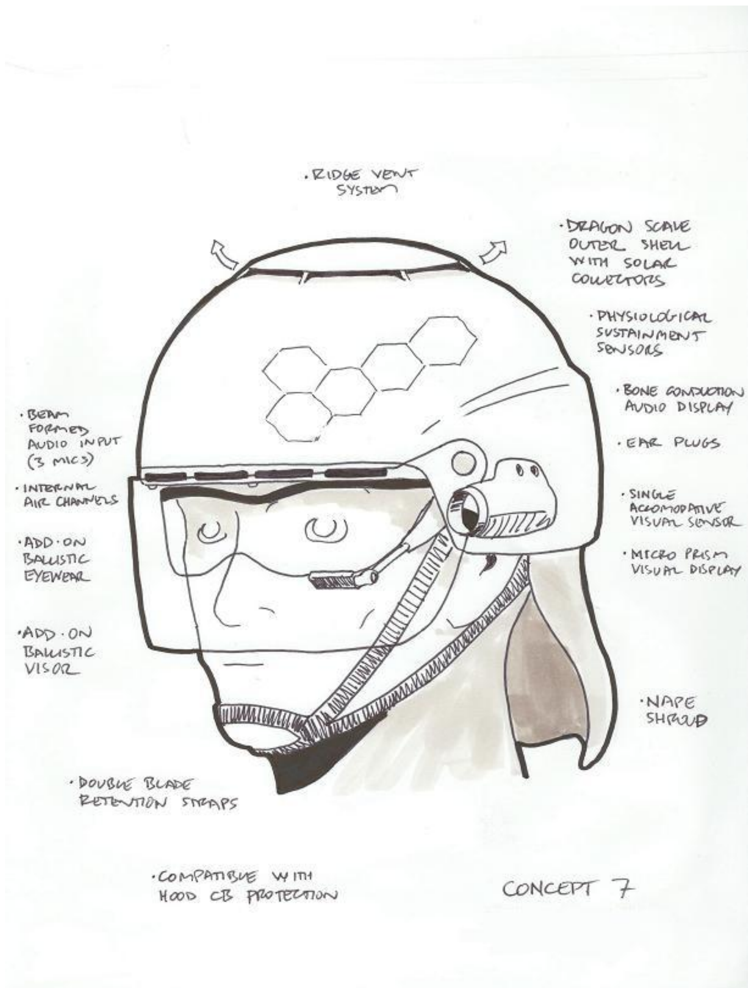


Figure 18: Concept 7 - Sustainability/Mobility

Concept 7 features a two-layer shell: the first layer consists of a one-piece ballistic shell and the second layer comprises interlocking, overlapping armour tiles with a solar collector covering on the tiles of the helmet cover. The solar collector tiles are intended to provide an ongoing trickle charge to soldier-borne power supplies. The impact liner consists of a Coolmax layer next to the skin followed by a hypercell comfort layer and a high-impact attenuating material. A user-specific or custom-moulded fit is provided to minimize any pressure point or contact discomfort. The Coolmax layer can be removed and washed and the impact materials are perforated for convection of heat and sweat vapour that would be ventilated out of the helmet through a ridge vent. A flexible, ballistic nape shroud is provided to protect the back of the neck from ballistic threats and solar exposure.

The visual display includes a microprism display device. An interchangable enhanced vision sensor is mounted at the side of the helmet where the connector can accept a day camera, night vision sensor, or thermal sensor. The audio display is provided through bone conduction transducers and speech input is achieved using a beam-formed array of microphones embedded in the brim of the helmet.

The CB mode employs a standard mask and head harness with a single, low-profile, low-volume canister with a service-life indicator. A family of canisters is available to suit longer durations and different threats.

Sustainment focused physiological sensors are also incorporated.

4 Feature and Capability Downselection

The following section outlines the downselection goals and approach for identifying and resolving the most successful features and capabilities of the seven concepts into the four new concepts that would progress into the Digital Model Development phase. Summary review comments are provided in this section for each of the seven designs.

4.1 Downselection goals

The downselection process involved an analysis of the initial seven concepts with the ultimate goal of reducing the number of concepts to progress into the digital phase. The aim of the downselection process was not to simply accept or reject the initial seven concepts, but rather to retain the best ideas from those concepts and advance those ideas to the Digital Model phase of the project. The mechanism for advancing these best ideas was to incorporate them into four new designs. It was essential at this stage of the project to maintain as much design diversity as possible across the four designs. As well, opportunities for improving the four designs with new design innovation were considered and incorporated as appropriate. A key feature of the downselection process was the need to maintain traceability of all design ideas so that even ideas that were rejected would not be lost to the project.

4.2 Downselection Approach

The downselection approach consisted of five steps:

1) A review of the initial concept designs with the SIHS subsystem teams.
2) An engineering review of the designs, performed by the industrial team.
3) A human factors review of the designs, performed by the industrial team.
4) A collation of the new design ideas generated by the three review phases.
5) The creation of the new design concept drawings and descriptions.

4.3 Summary Review of Concepts

Comments from the SST meetings and the engineering and human factors reviews are summarized below for each concept.

4.3.1 Concept 1

Generally, Concept 1 was well liked for its modularity, mission configurability, and the light, low profile nature of the design. However, at the integration team meeting, it was suggested that the scalable nature of concept 1 be further extended so that ballistic protection could be completely removed, leaving only a headband containing visual and audio sensors and displays. An initial concept drawing showing this headband version is presented in Figure 19.

The biggest challenge to this headband configuration is the stability and securement of the system when bearing the weight and balance issues associated with the microprism display and the enhanced vision sensor. Considerable design discussion focussed on this stability issue and it was concluded that it could be achieved with the addition of a headband strap and possibly the use of some form of buttressing support at the sides of the head.

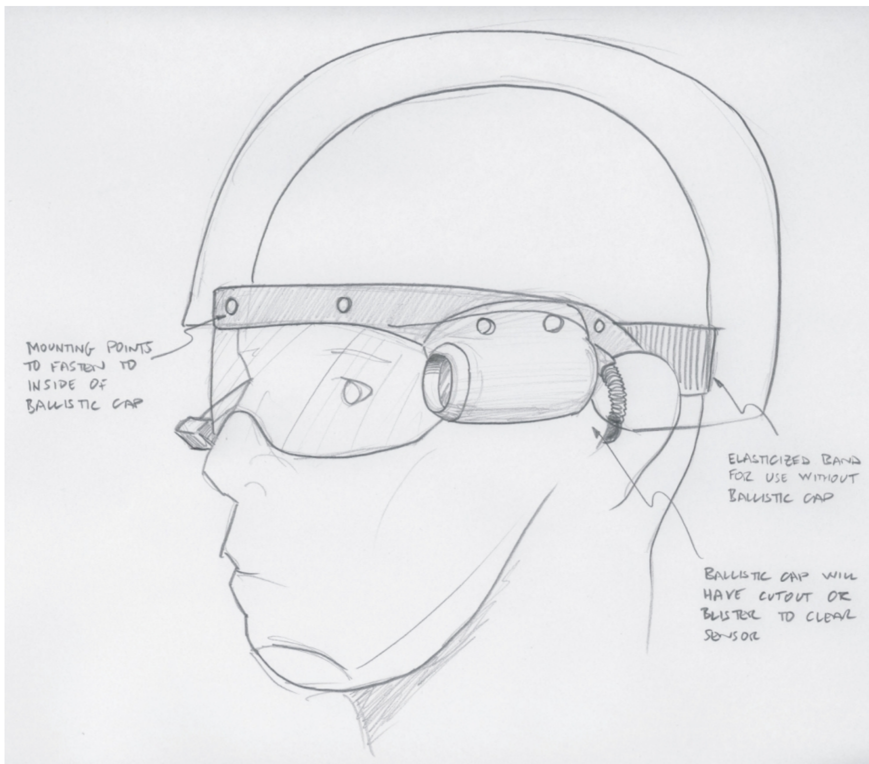


Figure 19: Concept 1, Headband Version

The concept of a soft armour layer over a hard armour shell was considered a viable option but further investigation and testing of this configuration was recommended to confirm that the ballistic and impact requirements could be achieved. For the assaulter role, the Head/Shell SST determined that the first shell layer should be capable of protecting against 0.1 grain fragments to a V_{50} of 500 m/s and the second layer, in combination with the first, would protect against 1.1 grain fragments to a minimum V_{50} of 650 m/s.

The microprism display in Concept 1 was considered a viable option for this design given the need for a small, light and robust device that can orient the display into a variety of positions. The headband design may need to provide a universal hotshoe connector to enable the display and the vision sensor to be exchanged between the left and right sides depending on the preferences and needs of the wearer.

The in-ear Quiet Pro device was seen to provide many advantages to a concept that emphasizes modularity, minimalism, and light weight. A small device that combines audio display, speech input, protection, and transparent hearing is a compelling solution. The speech and communications SST raised some concerns with the helmet shell coverage obscuring or altering the quality of the device's transparent hearing. The possibility of using an external microphone system on the shell connected to Quiet Pro was discussed, however new concerns with connecting and disconnecting to the shell microphones may be a concern when adding the first layer shell to the headband. It was concluded that this in-ear system had many advantages worthy of being retained in the design and that these concerns would be addressed in subsequent design efforts.

4.3.2 Concept 2

Concept 2 extends coverage down over the sides of the head and top of the neck, and the mandibular guard serves to provide some protection to the jaw and lower face. The Head/Shell SST concluded that the mandibular guard concept was worth retaining given our knowledge of fragmentation injuries to the face and neck due to Improvised Explosive Devices (IED) in Iraq. However, the mandibular guard concept comes with several concerns. In Canada's previous Combat Vehicle Crewman (CVC) project the extra weight of a mandibular guard proved to be a significant design challenge. In the case of the CVC helmet, the solution was to provide a system with lighter weight impact foam cushioning behind the hard outer shell of the guard. As well, it may be possible to provide the necessary protection to critical areas of the face and neck without the weight of a full mandibular guard by employing a partial mandibular guard. The other concern with any mandibular guard is the interface between the soldier's head and a shouldered weapon. Any modular mandibular guard design would also need to be attached securely and detached quickly in the field without special tools. The team had similar concerns about the mandibular guards in Concepts 5 and 6.

Concept 2 employs a microprism display in a dashboard configuration and is deployed inside the visor. Positioning the display inside the visor may require the shape of the visor to be extended forward to provide adequat clearance. Angling the visor forward may introduce visual distortions when viewing through the visor.

As with Concept 1, the Speech/Comms SST noted concerns with the effectiveness of the Quiet Pro transparent hearing given the extended helmet coverage at the sides down to the neck.

4.3.3 Concept 3

Concept 3 and several of the other designs featured visual displays and sensors attached to the outside of the ballistic shell. The effect of these components on ballistic protection was discussed in the Head/Shell SST to determine if these items could present a secondary projectile threat to the wearer. The team concluded that attachments to the outside of the helmet would more likely add to the total protection of the helmet instead of compromising the level of ballistic protection. Therefore, there was no need to add more protection over the add-on components or encase the components in the shell.

Concerns were also raised with the possibility of blunt impact and ballistic threats striking add-on helmet components, resulting in neck injury to the wearer. The Head/Shell SST concluded that, to minimize the risk of neck injury, add-on components should be designed to release from the helmet at a force that would not pose a risk to the neck.

Concept 3 featured active head cooling. The question of airflow direction was reviewed (e.g. back-to-front vs. front-to-back helmet airflow). There were concerns that a front-to-back configuration could cause expired air and possibly dust to go up and into the eyes and eyewear. For this reason, back to front cooling was considered preferable, although warm, humid air passing over the head to the face may increase the liklihood of visor and eyewear fogging. Further testing will be required. Some concerns were raised regarding fan noise in the shell of Concept 3 affecting the wearer's ability to hear their audio display. Any fan used in any of the concepts will have to be evaluated with regards to noise generation and the impact on audio devices.

While the appropriateness of the LOE and Virtual Retinal Display (VRD) displays remains to be verified, the Vision SST concluded that these could be viable display options and should be retained in the downselection. Several design challenges would need to be overcome: a reliable retraction mechanism for the displays; adjustments for eye alignment; bulk to the brim area of the helmet; light detection by the enemy, etc.

Full ear cup displays have the advantage of providing high fidelity audio information and protection in the one device. However, there are several usability issues associated with this technology. Ear cups introduce a source of skin pressure on the head around the ears and can be a source of sweating and thermal discomfort. However, members of the Speech/Comms SST agreed that, until we are able to objectively compare the audio performance of in-ear and bone conduction systems, an ear cup design should be progressed to the next design phase.

The use of an external microphone array on the Concept 3 shell offers a number of audio applications to the wearer. The array can be used to recreate the 3D audio soundscape and maintain sound localization ability; range gated hearing can be used to set a listening range window for the system; aural focussing can be used to listen in to a very specific location regardless of head position; and beam-formed focussing at the mouth can be used to improve speech input in a high noise environment, even with a mask.

Following further investigation of the double scrub CB filtration concept by the Respiratory SST, the idea was rejected due to humidity concerns between the first and second filtration stages. Since the air in the double scrub system would first pass over the head, it would be humidified by the moisture from the head before being routed through the mask to the respiratory canisters on the face. High humidity air can foul a CB canister leading to lower performance and shorter service life.

The use of a compression system (e.g. ski-buckle, compression flaps) to seal the mask to the balaclava will pose a design challenge to achieve a system that applies an even force around the face seal and accommodates different facial shapes.

The integration of a laser sensor array in the shell of Concept 3 may prove to be impractical when adapting the helmet to different terrain camouflage. It may be more suitable to incorporate the laser sensors into a helmet cover design that could be interchangable according to camouflage needs.

4.3.4 Concept 4

Concept 4 employs a mesh liner suspension system. Upon review, there was some concern that the mesh suspension alone may not prove stable enough to maintain the registration of key information devices on the head (e.g. the visual display alignment with the eye).

The Speech/Comms SST emphasized that the capability of bone conduction transducers to spatialize three-dimensional sound needed to be investigated. The U.S. experience with bone conduction transducers in high amplitude, low frequency environments (e.g. riding in a tracked vehicle) has suggested that the vibrations of the background sounds may also be picked up by the bone conduction transducers, thereby distorting the sound signal. Similar concerns exist for speech input devices that employ transducer technology (e.g. gel microphone). As well, the choice of a crown placement for the gel microphone may introduce pressure point discomfort requiring other locations to be identified.

In the CB mode, all information display capabilities should remain unchanged from the non-CB mode. Bone transducers need to be in contact with facial or head bones, so the use of this technology becomes more challenging when the user must wear a balaclava hood and mask. The use of redundant transducers built into the balaclava was considered as well as the switch to an open speaker option in the CB mode. These options will be explored further. While there are several outstanding concerns with the use of bone conduction, the bone conduction communications system should be retained and progressed into the Digital Model phase for now, while additional study is carried out.

4.3.5 Concept 5

Concept 5 comes closest to an encapsulated design. With the goal of a highly protective helmet the Head/Shell SST was concerned with the weight and load forces of such a helmet on the head and neck. As well, since Concept 5 employs a crushable liner for maximum impact and backface deformation protection, the liner would need to be inspected and changed out on a regular basis during heavy use.

The suggestion of a double or biocular LOE display has resulted in considerable debate in both the Vision SST and the industrial design team. Arguments in favour of a biocular display suggest that visual performance may be improved when displaying a complex image (e.g. map, video) since both eyes can be employed. Opponents of the idea suggest that a second display is an unnecessary cost; will occupy both eyes and reduce situation awareness of the free-field visual surroundings; and they do not believe that a wearer could effectively attend a different image to each eye. Since the question was not resolved it was decided to progress the biocular display into the Digital Model phase, while continuing to study the issue.

Key to the effectiveness of the Concept 5 design is an effective, efficient means of connecting the mandibular section, while still achieving the necessary seal between the mandibular guard and helmet and visor for CB protection.

This design employs a novel CB filtration technology: monolithic carbon tubes. Monolithic carbon tubes provide the benefit of low airway resistance during inhalation. However, little is known about the balance between low resistance and airflow filtration capacity, the dimensional characteristics and possibilities with such a technology, and the manufacturability issues. This technology will be progressed to the Digital Model phase and these questions will continue to be investigated.

Concept 5 employs a neck ring to mate a seal between the head and a torso garment in the CB mode. Further design review of this concept suggests that it may be impractical to wear in the non-CB mode, difficult to achieve a quick connection, and restrictive to head/neck mobility. As described in Concept 3, the double scrub CB system was rejected by the Respiratory SST, and will not be progressed into the next design phase. Therefore, head cooling would need to be performed with air or filtration levels matching respiratory requirements since the cooling airflow could not be easily isolated from the face and eyes, even though exspired air would be filtered through the monolithic carbon tube canisters in the mandibular guard.

4.3.6 Concept 6

Concept 6 includes biocular LOEs, ear cup audio displays, and a laser detecter array, which have already been commented on in previous concepts. Unique to this concept is the use of multiple visual sensors grouped centrally at the brim of the helmet to reduce the potential for visual offset problems with sensor placement too far away from the normal line of sight. While it may be possible to provide for several different image sensor fusion combinations in this design there is some concern that the sensor form factors may create a overlay extended brim overhang. This overhang could greatly reduce vertical field of view for the soldier and require considerably more head and neck movement in vertical threat environments (e.g. urban terrain).

Concept 6 employs a detachable mandibular guard, with integral CB protection, that is secured to the base of the helmet and mated with the visor. Achieving an effective CB seal is a significant design challenge. Several design options for achieving a seal with the visor were considered and a compressive seal in a rubber well in the mandibular guard was selected for now; accepting that considerably more design and testing will be required before a suitable solution can be confirmed.

To create a CB seal between the head and torso, a gaiter material deployable from the mandibular guard base, which could overlap with a CB protective dickie worn on the torso, was seen to offer a simple, effective solution. Alternatively, the torso garment could include a permanently affixed balaclava hood, constructed of thin semi-permeable material, which could be easily deployed over the head in the event of a CB attack.

The use of an active camouflage system for a helmet is compelling and a chameleon textile controlled by an array of visual sensors may well prove effective. Generally, members of the Vision SST agreed that too little was known about potential technologies for achieving active camouflage and that, for now, this area should be investigated further before considering it in any concept design.

4.3.7 Concept 7

Concept 7 employs many of the light, modular, low bulk technologies (e.g. visual and auditory displays, speech input) that were included in the previous six concepts. However, there were some important differences.

The ridge vent system, while providing a novel means of passive helmet venting, raised concerns among the Head/Shell SST regarding the potential for structural weaknesses in the design. This structural weakness may reduce the effectiveness of the helmet for impact, ballistic and blast protection. While this potential for weakness could be resolved with an overlapping armour design concept, this solution may only serve to greatly increase the weight of the helmet shell.

The use of overlapping armour tiles to up-armour the helmet shell and a nape shroud to provide ballistic and solar protection to the back of the neck offer several benefits but little is known about the effectiveness of either system. For this reason both capabilities have been progressed to the Digital Model phase and will be investigated more fully to confirm their protective capabilities.

5 New Designs

At the conclusion of the downselection process, desirable features and capabilities from the original seven concept designs were reconstituted into four new designs that will be pursued in the Digital Model phase. The accuracy of the concept drawings was also improved and colour details were incorporated.

The initial seven concepts were primarily unscaled artist's renditions of the concept ideas. As part of the process to create the new designs, the fidelity of the concept images was improved to better represent the scale of the helmets and their components. Digital scale models were created for available helmet components including visual sensors and displays, respiratory equipment and sample helmet shells. A digital headform model, representing an average medium-sized Canadian soldier's head was also used to scale the new concept images. Figure 20 shows the digital models of some helmet components and the digital headform being used for the SIHS project.

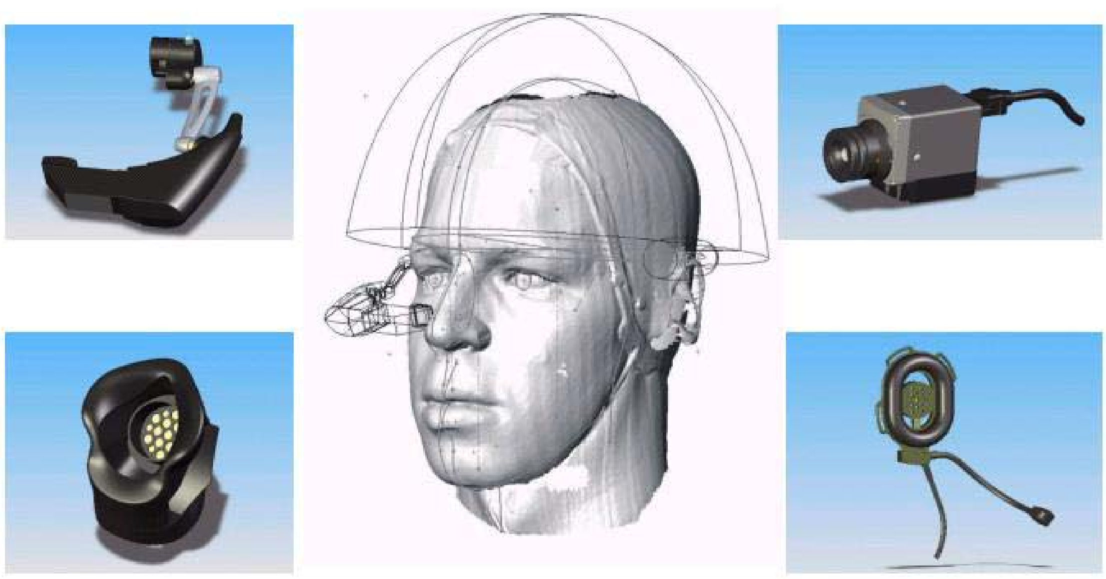


Figure 20: Concept Fidelity Effort

This section presents the four new designs. Tables detailing the design features and capabilities are included in Annex D.

5.1 Concept A

Concept A is derived mostly from Concepts 1 and 2, and the addition of new design ideas, as shown in Figure 21.

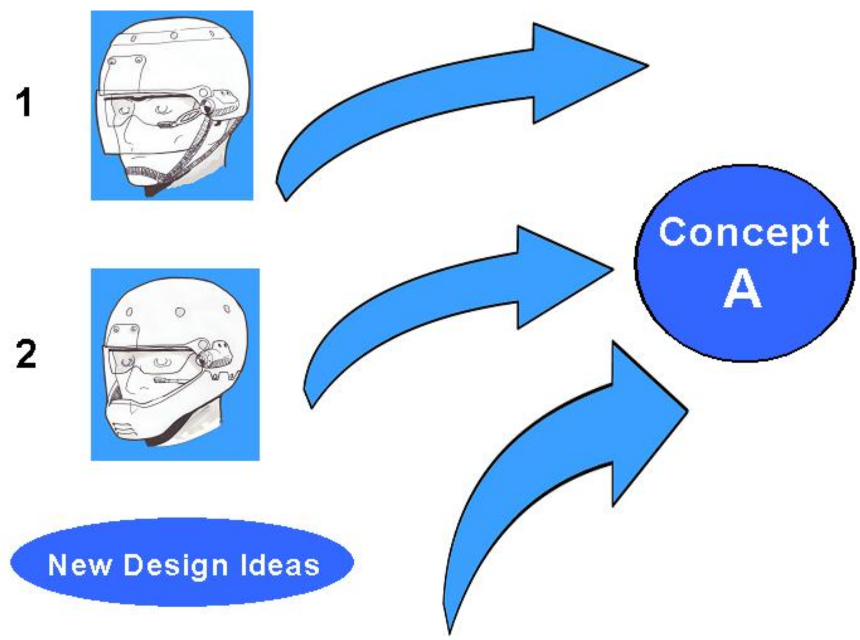
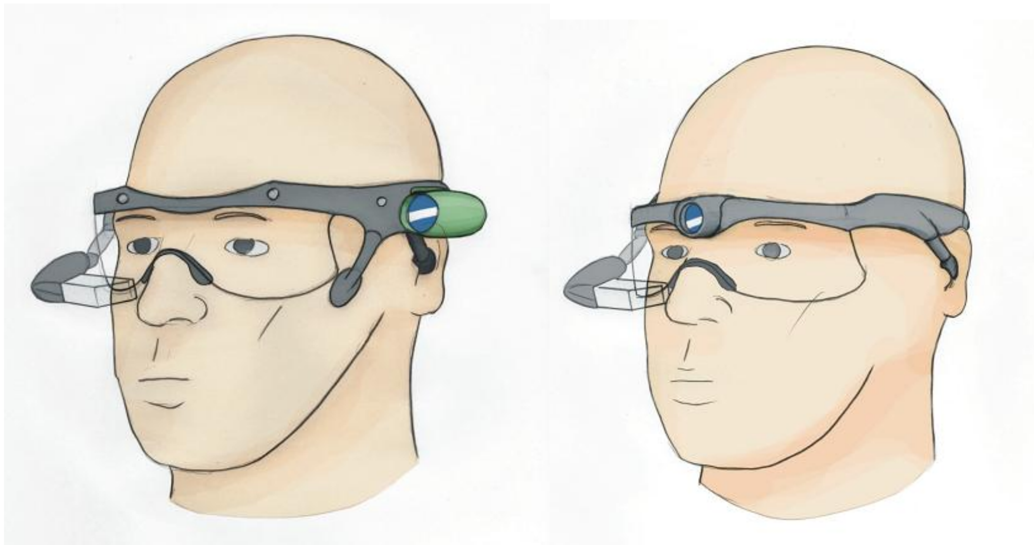


Figure 21: Heredity of Concept A

Concept A is a highly modular helmet that can be mission configured from its simplest, non-shell base layer (layer 0) consisting of a C4I spectacle headband, to the light armour shell layer with add-on ear armour and mandibular guard (layer 1), and finally up to the higher fragmentation layer of protection (soft shell) with a ballistic visor (layer 2). Many of the features and armour components are configurable in each of layers 1 and 2. The concept is explained in more detail below.

5.1.1 Concept A - Layer 0

The base layer for Concept A is shown in Figure 22. In its most basic configuration it comprises a spectacle headband featuring ballistic eyewear and an in-ear audio input and display capability. A microprism display and an enhanced vision sensor can be added to either side of the spectacle headband as required.



Attached Sensor Fiber Optic Sensor

Figure 22: Concept A - Layer 0

The spectacle headband (Figure 22 – attached sensor) includes interchangable ballistic lenses (e.g. clear, solar, low light, laser) and stabilizing pads at the cheek bones to prevent the spectacles from tilting side to side from the weight of the microprism display and enhanced vision sensor. The in-ear Quiet Pro audio display and speech input device is integrated into the headband.

To reduce the weight of the enhanced vision sensor on the head and to position the sensor head as close to the wearer's natural line of sight as possible, the use of fiber optic technology was considered (Figure 22 – fiber optic sensor). In this design the enhanced vision sensor is replaced by a lens with a fiber optic bundle backplane behind the lens. The fiber optic bundle transmits the visual image, collected by the lens, to any one of a number of digital image processors worn on the torso (e.g. day video, night vision, thermal) where the processed image is returned to the microprism display on the spectable headband. Using this technology the weight on the head could be greatly reduced and the need to carry separate optical devices for each sensor spectrum would be eliminated by the common zoom lens. It may also be possible to split the common image to more than one image processor simultaneously thereby achieving image fusion with no parallax or image distortion.

5.1.2 Concept A - Layer 1

Layer 1 is added on top of the base layer 0 (see Figure 23). It is a hard shell layer made of thin, high-impact material that provides cranial and nape protection and has a liner/suspension system incorporating an impact liner, comfort pads, and a 3D weave material to enhance passive airflow. Airflow channels in the liner circulate air from the front to the back of the helmet to reduce the hot, humid air collecting in the crown of the helmet.

The helmet shell could be freely mounted over the spectacle headband and each secured to the head independently or the spectacle device could be secured to the helmet as long as the spectacle lenses and the microprism display can remain fixed on the face and independent of helmet movement.

Figure 23: Concept A - Layer 1

In the Layer 1 configuration, ballistic ear guards can be added to the layer 1 shell as shown in Figure 24. The ear guards provide further ballistic protection, as well as incorporating a hot-shoe mount for electronic devices and a mounting surface for other items. The ear guards can be added quickly to the layer 1 shell in the field with only the use of a multi-tool.

Figure 24: Concept A - Layer 1 with Ear Guards

To increase maxilla-facial and neck protection, a mandibular guard can also be added to layer 1 ear guards as shown in Figure 25.

Figure 25: Concept A - Layer 1 with Mandibular Guard

5.1.3 Concept A - Layer 2

Concept A can be further up-armoured for fragmentation and additional impact protection by adding a soft shell layer. This layer comprises soft armour material, a resilient lattice foundation and a thin stiff outer cover to protect the soft armour from water. A half-face ballistic visor can also be added with a snap-on attachment. See Figure 26

Figure 26: Concept A - Layer 2

CB protection is provided by a conventional mask with a mono lens and head straps. The mask creates a compression seal against a semi-permeable balaclava hood. A service life indicator is built into each canister.

5.2 Concept B

Concept B is derived mostly from Concepts 3, 5 and 7, and the addition of new design ideas, as shown in Figure 27 below.

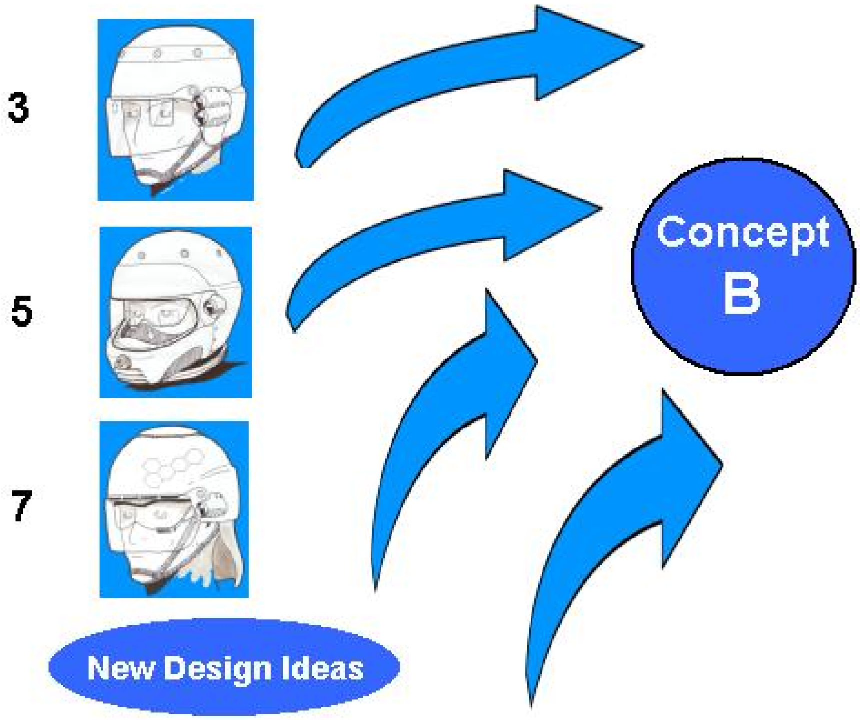


Figure 27: Heredity of Concept B

This concept focuses on a helmet with significant display and sensor capabilities and increased CB integration.

Figure 28 shows Concept B in the non-CB state. The helmet includes a single ballistic layer with an add-on ballistic nape shroud for ballistic and solar protection to the back of the neck. Eye protection includes ballistic eyewear and a retractable visor.

Two interchangeable visual sensors are grouped at the eyeline and a see-through, retractable, augmented reality display (LOE) is built into the brow of the helmet. Audio display and speech input are accomplished with a bone-conduction system integrated into the harness and comfort layer of the helmet. An audio array provides spatially accurate transparent hearing. Power and data cabling for electronic vision and auditory systems are integrated into the hard shell in a technology "halo" as shown.

Figure 28: Concept B, Non-CB version

Figure 29 shows a rear view of Concept B. An integrated low-power fan at the back of the helmet pulls air through airflow channels designed into the impact liner layer to provide active head-cooling and demisting.

Figure 29: Rear view of Concept B

The CB mode for Concept B is shown in Figure 30 below. The CB mask is a component system featuring a combined mask with oronasal cup and a mono lens that was pulled into the face using ratchet straps. Key to the mask design is the ability to add the mask to the helmet without removing the helmet from the head.

A thin, flexible, semi-permeable balaclava hood provides cutaneous protection and connection to the CB plus system on the torso. A seal is created between the mask and the hood through compression. The double, mask-mounted canisters employ monolithic carbon tube technology and include an integral fan behind the canister to circulate air up to the top of the mask through internal channelling and then circulate the air over the surface of the mono lens to prevent fogging. This fan-circulated air also provides a positive pressure inside the face seal to improve the protection factor of the mask. A portion of the fan-circulated air could also be directed to wash over the expiratory valve to further improve mask protection. It may also be possible to employ a pressure sensor system that could increase fan air pressure in proportion to the negative pressure normally associated with inhalation to further reduce the risk of a seal break. Canisters include a service life indicator to ensure that adequate filtration protection is available to the soldier and that canisters are not disgarded before their available capacity had been completely used.

Also shown in Figure 30 is a helmet cover comprised of a solar collector weave material to harvest solar power for the purpose of trickle charging the soldier’s power supply. The helmet cover also includes integral laser detectors.

Figure 30: Concept B in CB mode

5.3 Concept C

Concept C is derived mostly from Concepts 4 and 6, and the addition of new design ideas, as shown in Figure 31 below.

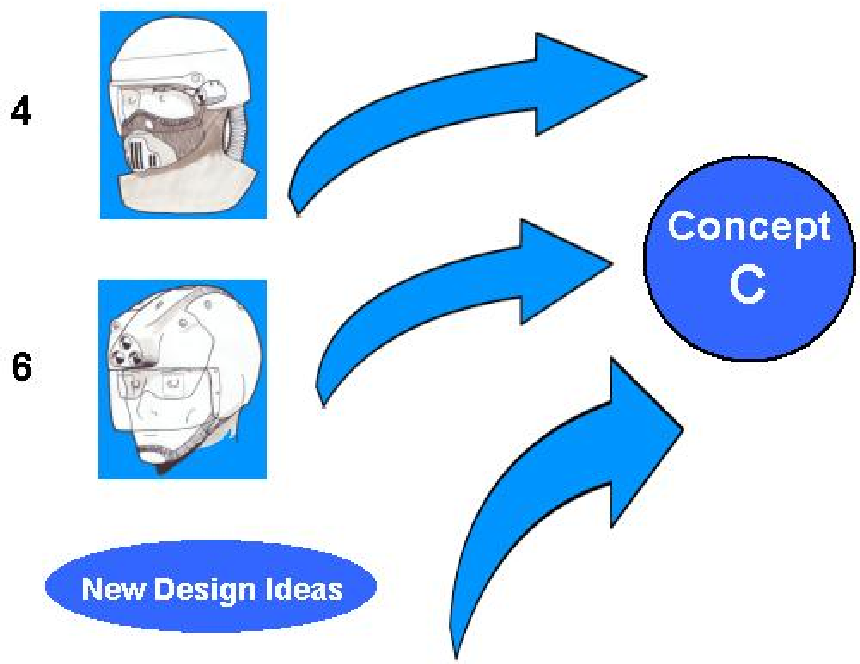


Figure 31: Heredity of Concept C

Concept C is focused on optimized surveillance and information display, while providing improved shell coverage to the neck and jaw area. Two alternative versions of Concept C are shown in Figures 32 and 33 below.

The enhanced shell coverage includes partial mandibular guards that are designed to protect vital structures below the ear and along the jaw and face. As well, mandibular impact pads are included to provide an "up-armouring" capability for improved impact protection and helmet stability on the head. The mandibular guard design is shown in Figure 32 without the impact pads and in Figure 33 with the pads installed.

In the non-CB mode head cooling is achieved through passive airflow channeling from the front to the back of the helmet. Heat and humidity, generated at the head, convect through the Coolmax/hypercell comfort layer and migrate through airflow holes that perforate the impact liner, up to the main airflow channels under the shell where it is cleared from the helmet.

Concept C retains the biocular display concept. Figure 32 shows biocular microprism displays that retract from hangar locations into the halo at the brim of the helmet. Figure 33 shows an alternative design featuring dual VRD displays. The enhanced vision sensor system is positioned centrally between the eyes and includes an optical zoom lens with a fiber optic backplane collector. Imagery is transmitted to image processors (e.g. day vision, night vision, and thermal) worn on the torso via a coherent fiber optic bundle in the helmet halo (i.e. the band around the helmet that acts as a conduit for power and data). White light and IR illuminators are also mounted in the halo on either side of the optical lens.

Concept C also features highly integrated ear cups for 3D audio display and protection, as well as active protection and transparent hearing through an audio array system around the shell of the helmet. The same array is used to generate the beam-formed speech input capability.

Figure 32: Concept C - Version 1

Figure 33: Concept C - Version 2

Concept C can be up-armoured with a higher threat ballistic cap for use in surveillance, reconnaissance and OP missions and an add-on ballistic visor, as shown in Figure 34.

Figure 34: Concept C with high velocity ballistic cap

The CB protection system for Concept C is shown in Figure 35. Concept C features a fully integrated positive pressure CB system. The face-piece mask is mated to a rubber seal around the face of a balaclava hood constructed of semi-permeable material. A ratchet system is used to pull the mask into the face with an adjustment knob at the back of the helmet.

Both filtered and unfiltered air is supplied from a blower system on the torso. A hose supplying unfiltered air from the torso blower is fed into the back of the helmet to provide cooling to the head area covered by the balaclava hood. A separate hose supplies filtered air from the filter blower system to a valve system at the cheek of the mask. The filtered air circulates through ducts in the mask to cool the face and demist the visor. The air is then drawn into the oronasal cup through valves during inhalation. Expired air is then exhausted directly from the oronasal cup. Positive pressure airflow is also directed to wash over the exhale valve to prevent any infiltration.

Canisters on the torso filter blower system are hot-swappable and include a service life indicator with an auditory warning/alarm provided to the helmet's audio display.

Figure 35: Concept C - CB version

5.4 Concept D

Concept D is derived mainly from Concepts 5 and 6, and and the addition of new design ideas, as shown in Figure 36 below.

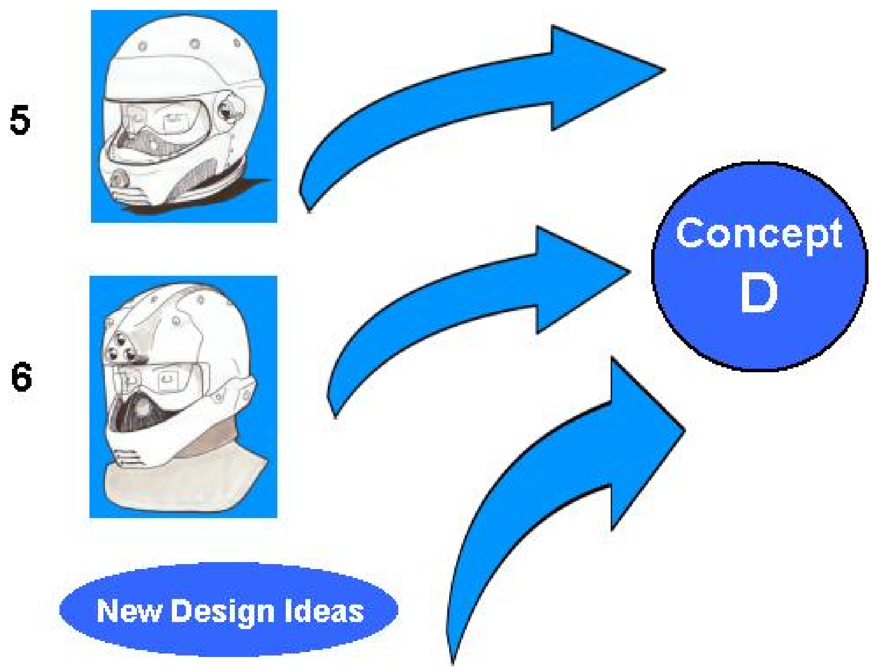


Figure 36: Heredity of Concept D

Concept D is a single layer, high coverage helmet focusing on high protection against both ballistic and CB threats.

Similar to Concept 5, this concept employs a single ballistic shell, crushable impact liner, and a webbing/leather suspension system (see Figure 37). Coverage extends over the ears to protect vital areas in the neck and a ballistic visor is included to protect the upper face. The visor is an exchangable concept that would be affixed to the helmet securely with a gasket seal to support a transition to CB protection if necessary.

An active cooling fan is integrated into the shell design for providing airflow circulation over the head space created by the webbing/leather headband suspension. Airflow is also channeled to the front of the helmet for defogging the visor.

The visual display includes a single virtual retinal display lens that is deployable from the brim of the helmet. The 3D audio display system is integrated into the protective ear cups and includes transparent hearing through an array of audio sensors around the shell of the helmet. This array also provides the beam-formed capability for speech input.

Enhanced vision is provided through an optical zoom lens with a fiber optic backplane collector at the side of the helmet shell. Imagery is transmitted to image processors (e.g. day vision, night vision, and thermal) worn on the torso via a coherent fiber optic bundle (i.e. the band around the helmet that acts as a conduit for power and data).

Figure 37: Concept D

Two different artist renditions of Concept D in the CB state are shown in Figures 38 and 39 below. The CB state for Concept D is a fully integrated, enclosed positive-pressure system. The helmet is sealed at the neck and filtered air is provided to the helmet for breathing, cooling and defogging via a hose from the torso-mounted canister and blower system.

The key to the CB protection system is a mandible attachment that secures to the helmet visor and around the base of the helmet shell, and includes an oro-nasal mask and deployable ring that stores a tensioned neck gaiter of semi-permeable CB-protective material. The position of the oro-nasal mask is controlled by ratchet knob at the front of the mandible so that the mask can be withdrawn (non-CB threat) or moved into the face to achieve an oro-nasal seal (CB threat state). Figure 39 shows an alternative design that incorporates the visor permanently into the mandible. In the event of a CB threat the mandible and visor would be secured directly to the helmet shell.

The neck gaiter is tensioned around a deployable ring at the base of the mandible/helmet base. When the ring is pulled down the gaiter is extended down over a CB-protective dickie covering the neck (the dickie would be a torso garment worn with the CB-plus system).

Figure 38: Concept D - Version 1 **Figure 39: Concept D - Version 2**

Concept D could easily migrate towards a fully-encapsulated design as shown in Figure 40.

Figure 40: Concept D - Fully Encapsulated

5.5 Feature Function Traceability

One goal of the SIHS process was to maintain traceability of ideas throughout the downselection process. This section describes the disposition of those design ideas from the initial concepts through to the new downselected concepts, and includes the addition of new design ideas to the final four designs.

Figure 41 provides a high level summary of the relationship between the initial concepts and the resulting downselected four new concepts. In general, all concepts, in their non-CB and CB modes, were retained to some degree in the four new designs.

INITIAL CONCEPTS	NEW CONCEPTS			
	A	B	C	D
1				
2				
3				
4				
5				
6				
7				

Figure 41: Feature and Function Traceability

Two tables, provided in Annex E, outline the disposition of features and capabilities from the initial seven concepts to the final four new designs. The first table lists all the features/capabilities associated with each of the seven initial designs and also indicates where they reside in the new designs. As well, any feature/capability that was eliminated is highlighted (red colour and CAPS) and any new design element that was incorporated into the four new designs is indicated (blue colour and italics).

In summary, all features/capabilities were retained in the four new designs with the exception of the following:

1. Mesh Suspension: Mesh suspension was rejected as a suspension system due to concerns with insufficient helmet stability and securement.
2. Double Scrub Filtration: The use of a double scrub system of CB filtration was eliminated due to concerns that the high humidity air from head cooling would foul the second (respiratory) canister, thereby reducing respiratory protection performance and duration.
3. Neck Ring: Using a neck ring to achieve a CB mating seal between the helmet and the torso garment was eliminated due to concerns with practicality of wear and difficulties in achieving a quick connection.

The second table in Annex E summarizes the listing of features/capabilities in the final four designs that will be progressed to the Digital Model Development phase.

6 The Next Phase

In the next phase of the SIHS design cycle (Digital Model Development phase), the four downselected concepts will be progressed into 3D digital Solidworks models. The digital models will be evaluated and analyzed for a range of design and human factors issues (e.g. anthropometry, fit/adjustability, compatibility, CB states and transitions, biomechanics, device performance, structural performance, thermal management, vision, auditory performance, maintainability, camouflage, etc). The results of these analyses will be used to further refine and downselect the designs for the Physical Model Development phase of the project. This process is summarized in Figure 42.

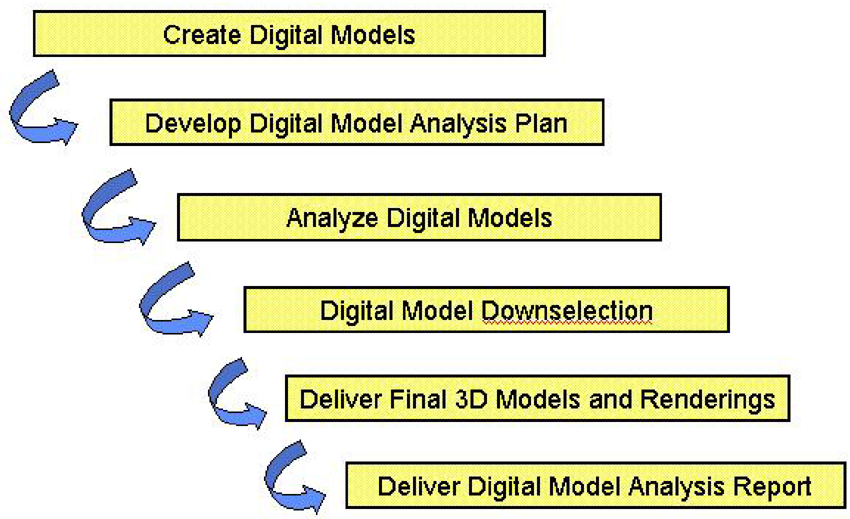
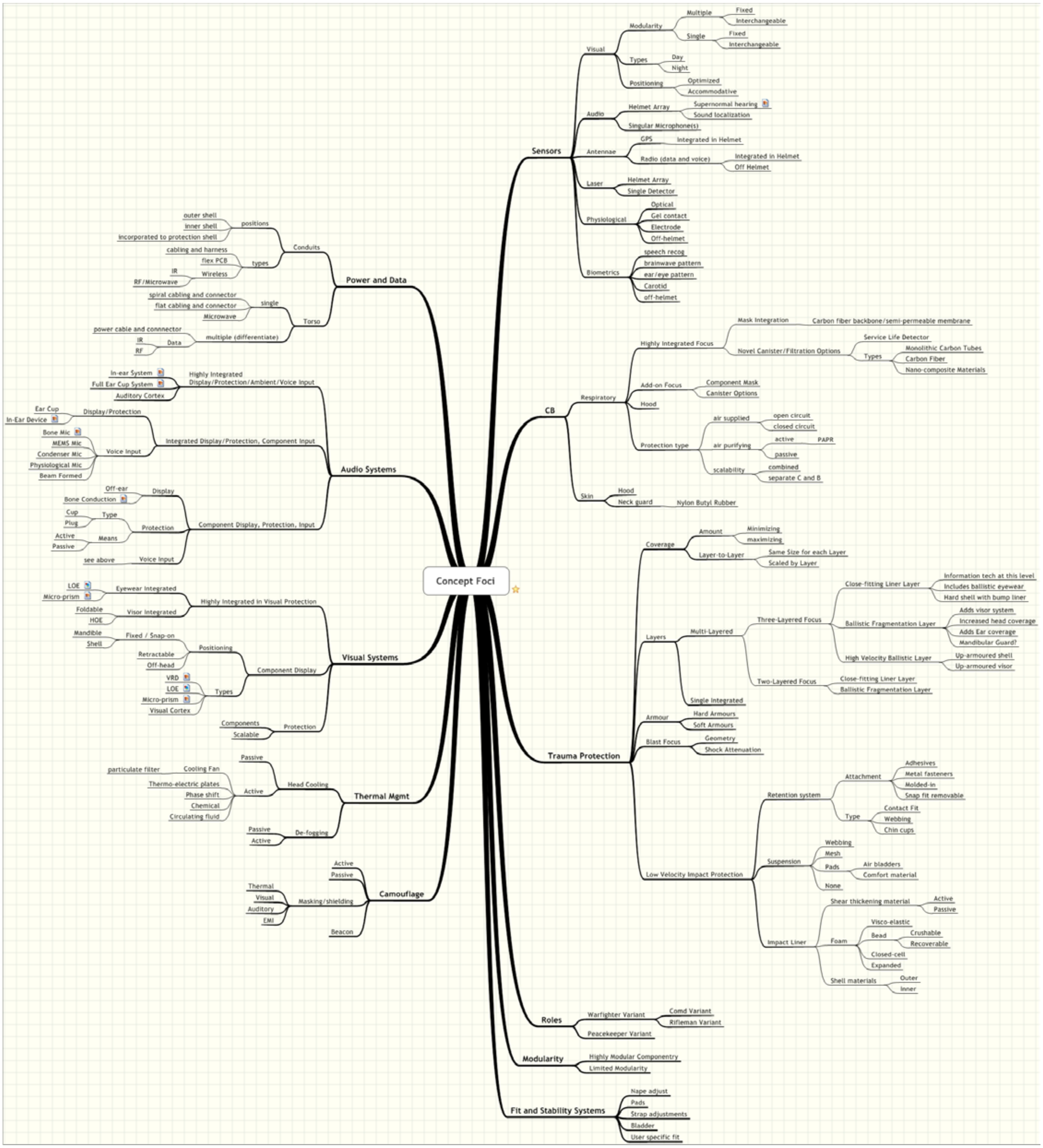


Figure 42: The Way Ahead

LIST OF ANNEXES

Annex A: Helmet Capability Brainstorming



Concept Foci
Sensors
Visual
Modularity
Multiple
Fixed
Interchangeable
Single
Fixed
Interchangeable
Types
Day
Night
Positioning
Optimized
Accommodative
Audio
Helmet Array
Supernormal hearing
Sound localization
Singular Microphone(s)
Antennae
GPS
Integrated in Helmet
Radio (data and voice)
Integrated in Helmet
Off Helmet
Laser
Helmet Array
Single Detector
Physiological
Optical
Gel contact
Electrode
Off-helmet
Biometrics
speech recog
brainwave pattern
ear/eye pattern
Carotid
off-helmet
CB
Respiratory
Highly Integrated Focus
Mask Integration
Carbon fiber backbone/semi-permeable membrane
Novel Canister/Filtration Options
Service Life Detector
Types
Monolithic Carbon Tubes
Carbon Fiber
Nano-composite Materials
Add-on Focus
Component Mask
Canister Options
Hood
Protection type
air supplied
open circuit
closed circuit
air purifying
active
PAPR
passive
scalability
combined
separate C and B
Skin
Hood
Neck guard
Nylon Butyl Rubber
Trauma Protection
Coverage
Amount
Minimizing
maximizing
Layer-to-Layer
Same Size for each Layer
Scaled by Layer
Layers
Multi-Layered
Three-Layered Focus
Close-fitting Liner Layer
Information tech at this level
Includes ballistic eyewear
Hard shell with bump liner
Ballistic Fragmentation Layer
Adds visor system
Increased head coverage
Adds Ear coverage
Mandibular Guard?
High Velocity Ballistic Layer
Up-armoured shell
Up-armoured visor
Two-Layered Focus
Close-fitting Liner Layer
Ballistic Fragmentation Layer
Single Integrated
Armour
Hard Armours
Soft Armours
Blast Focus
Geometry
Shock Attenuation
Low Velocity Impact Protection
Retention system
Attachment
Adhesives
Metal fasteners
Molded-in
Snap fit removable
Type
Contact Fit
Webbing
Chin cups
Suspension
Webbing
Mesh
Pads
Air bladders
Comfort material
None
Impact Liner
Shear thickening material
Active
Passive
Foam
Visco-elastic
Bead
Crushable
Recoverable
Closed-cell
Expanded
Shell materials
Outer
Inner
Roles
Warfighter Variant
Comd Variant
Rifleman Variant
Peacekeeper Variant
Modularity
Highly Modular Componentry
Limited Modularity
Fit and Stability Systems
Nape adjust
Pads
Strap adjustments
Bladder
User specific fit
Power and Data
Conduits
positions
outer shell
inner shell
incorporated to protection shell
types
cabling and harness
flex PCB
Wireless
IR
RF/Microwave
Torso
single
spiral cabling and connector
flat cabling and connector
Microwave
multiple (differentiate)
power cable and connnector
Data
IR
RF
Audio Systems
Highly Integrated Display/Protection/Ambient/Voice Input
In-ear System
Full Ear Cup System
Auditory Cortex
Integrated Display/Protection, Component Input
Display/Protection
Ear Cup
In-Ear Device
Voice Input
Bone Mic
MEMS Mic
Condenser Mic
Physiological Mic
Beam Formed
Component Display, Protection, Input
Display
Off-ear
Bone Conduction
Protection
Type
Cup
Plug
Means
Active
Passive
Voice Input
see above
Visual Systems
Highly Integrated in Visual Protection
Eyewear Integrated
LOE
Micro-prism
Visor Integrated
Foldable
HOE
Component Display
Positioning
Fixed / Snap-on
Mandible
Shell
Retractable
Off-head
Types
VRD
LOE
Micro-prism
Visual Cortex
Protection
Components
Scalable
Thermal Mgmt
Head Cooling
Passive
Active
Cooling Fan
particulate filter
Thermo-electric plates
Phase shift
Chemical
Circulating fluid
De-fogging
Passive
Active
Camouflage
Active
Passive
Masking/shielding
Thermal
Visual
Auditory
EMI
Beacon

Annex B: Original Seven Concepts

CONCEPT 1	Focus	Concept
	Mobility Lethality	This concept focuses on a high mobility helmet that can be mission configured for functionality and protection. (e.g. an urban assault helmet that can be up-armoured for different threats).
Design Options:	**Selection**	**Comments**
Protection - Ballistic or Blast	Ballistic	1st layer = bump and moderate fragmentation protection, 2nd layer = higher fragmentation threats
Ballistic - One-Piece or Add-on Layers	Two Layers	1st layer = hard shell, light, thin, some penetration/frag prot., 2nd layer = soft armour with flexible lattice offset,
Ballistic - Coverage - Low or Medium or High	Low	low mass, low profile, coverage no lower than mid-earline
Ballistic Eyewear - Retractable or Add-on	Add-on	ballistic eyewear
Ballistic Visor - Retractable, Snap-on, or Add-on	Snap-on	half-face visor, snap on with the addition of second layer fragmentation protection
Mandibular Guard	No	
Impact - Fixed or Removable Components	Fixed	1st layer = recoverable material, 2nd layer = deformable lattice/soft armour deflection
Suspension - Leather or Mesh or Contact Pads	Contact pads	combined comfort/impact layer
Retention	Chinstrap	four point harness
CB Protection - Fully Integrated or Components	Components	mask with balaclava hood under helmet, hood material using semi-permeable technology
CB Protection - Positive or Negative Pressure	Negative	negative pressure mask
CB Protection - Single or Double Canister	Single	single, low profile, low volume (2-3hrs) cannister, family of cannisters to suit longer durations and threats, service life indicator
Modularity - Low or Medium or High	High	only mission essential componentry
Head Cooling - Active or Passive	Passive	air flow channeling the length of the helmet, 3D weave materials form channels.
Anti-Fogging - Active or Passive	Passive	anti-fog coatings
Visual Display - Integrated or Component	Component	snap on component, may need a hangar location on shell to stow when not in use
Visual Display - Types	Micro-Prism	small, light, robust
Visual Display Positioning - Retractable or Snap-on	Snap-on	snap-on but can articulate for positioning and stowage
Audio - High, Medium, or Component Integration	Medium	most integration exists in the in-ear technology
Audio - Display - Monaural or Binaural or 2D Horizontal	binaural	
Audio - Display - Types	In-ear	NACRE style
Audio - Protection - Active or Passive	Active	
Audio - Protection - Types	In-ear	
Audio - Voice Input - Types	In-ear	
Sensor - Visual - Singular or Multiple Sensors	Singular	
Sensor - Visual - Fixed or Interchangable Sensors	Interchangable	interchangable for day video, I2, or IR cameras
Sensor - Visual - Position - Optimized or Accommodative	Accommodative	locate beside ear at eyeline
Sensor - Audio - Array or Singular Mics	Singular Mics	in-ear
Sensor - Radio Antenna - Integrated or off-helmet	off-helmet	
Sensor - Laser - Array or Single Detector	Single	
Power and Data		integrated into 1st layer under hard shell

CONCEPT 2	Focus	Concept
	Mobility Survivability (ball.)	This concept focuses on a high mobility helmet that can be mission configured for functionality and higher protection. (e.g. an urban assault helmet that can be up-armoured for different threats).
Design Options:	**Selection**	**Comments**
Protection - Ballistic or Blast	Ballistic	1st layer = bump and moderate fragmentation protection, 2nd = higher fragmentation threats, 3rd = high velocity threats
Ballistic - One-Piece or Add-on Layers	Three Layers	1st layer = hard shell, some penetration/frag prot., 2nd layer = soft armour with flexible lattice offset, 3rd = hard armour
Ballistic - Coverage - Low or Medium or High	Low	low mass, low profile, no lower than mid-earline
Ballistic Eyewear - Retractable or Add-on	Add-on	ballistic eyewear
Ballistic Visor - Retractable or Add-on	Add-on	half-face visor, snap on with the addition of second layer fragmentation protection
Mandibular Guard	Yes	snap-on mandibular guard provides impact protection and mount for other devices
Impact - Fixed or Removable Components	fixed	
Suspension - Leather or Mesh or Contact Pads	Contact pads	contact pads mounted onto impact liner layer
Retention	Chinstrap	four point
CB Protection - Fully Integrated or Components	Components	mask with balaclava hood under helmet, hood material using semi-permeable technology
CB Protection - Positive or Negative Pressure	Negative	negative pressure mask
CB Protection - Single or Double Canister	Single	single, low profile, low volume (2-3hrs) cannister, family of cannisters to suit longer durations and threats, service life indicator
Modularity - Low or Medium or High	High	only mission essential componentry, armour levels to match threats
Head Cooling - Active or Passive	Passive	air flow channeling the length of the helmet, channelling moulded into impact liner layer.
Anti-Fogging - Active or Passive	Passive	anti-fogging coatings
Visual Display - Integrated or Component	Component	snap on component in mandible, hangar location built into mandible
Visual Display - Types	LOE or Microprism	
Visual Display Positioning - Retractable or Snap-on	retractable	retractable into dashboard configuration of mandibular guard
Audio - High, Medium, or Component Integration	Medium	most integration exists in the in-ear technology
Audio - Display - Monaural or Binaural or 2D Horizontal	binaural	
Audio - Display - Types	In-ear	NACRE type
Audio - Protection - Active or Passive	Active	
Audio - Protection - Types	In-ear	
Audio - Voice Input - Types	In-ear	
Sensor - Visual - Singular or Multiple Sensors	Singular	
Sensor - Visual - Fixed or Interchangable Sensors	Interchangable	interchangable for day video, I2, or IR cameras
Sensor - Visual - Position - Optimized or Accommodative	Accommodative	beside ear at eyeline
Sensor - Audio - Array or Singular Mics	Singular Mics	in-ear
Sensor - Radio Antenna - Integrated or off-helmet	off-helmet	
Sensor - Laser - Array or Single Detector	Single	
Power and Data		integrated into 1st layer under hard shell
Illumination Devices	IR and white light	mounted to the forehead area of the shell

CONCEPT 3	Focus	Concept
	C4I Survivability (CB)	This concept focuses on a helmet with significant display and sensor capabilities.
Design Options:	**Selection**	**Comments**
Protection - Ballistic or Blast	Ballistic	
Ballistic - One-Piece or Add-on Layers	One Layer	
Ballistic - Coverage - Low or Medium or High	High	coverage extends down to cover ears
Ballistic Eyewear - Retractable or Add-on	Addon	
Ballistic Visor - Retractable or Add-on	Retractable	snap-on, retractable visor, retracts over outside of helmet
Mandibular Guard	No	
Impact - Fixed or Removable Components	Fixed	impact liner with integral airflow channeling
Suspension - Leather or Mesh or Contact Pads	Contact Pads	contact pads mounted onto impact liner layer
Retention	Chinstrap	four point
CB Protection - Fully Integrated or Components	Components	combined mask/oronasal cup with mono lens, pulled into face with ski buckle or straps or pressed into face with wire mesh flaps
		balaclava hood (semi-permeable, thin, flexible) provides cutaneous protection and connection to CB Plus torso
CB Protection - Positive or Negative Pressure	Negative/Positive	double scrub - outside air for face and 2nd scrub of helmet air through oronasal cannisters (longer duration or lower volume)
		nape cannister is inserted into fan port thereby reversing fan to draw outside air through cannister to pressurize helmet
CB Protection - Single or Double Canister	Double	shallow, low profile design. Cannister layers are stackable to increase duration or adapt to threat mix, audio service life indicator
Modularity - Low or Medium or High	Medium	
Head Cooling - Active or Passive	Active	fan at back of helmet pulls air through helmet (front to back), draws air through channels in impact liner layer, low power fan
Anti-Fogging - Active or Passive	Active	fan powered airflow washes over eyewear
Visual Display - Integrated or Component	Integrated	display is integrated into the shell structure of the helmet
Visual Display - Types	LOE/VRD	see-through, augmented reality displays
Visual Display Positioning - Retractable or Snap-on	Retractable	retractable into brow of helmet
Audio - High, Medium, or Component Integration	High	
Audio - Display - Monaural or Binaural or 2D Horizontal	3D Audio	fully spacialized sound field, 3D localized sound sources, spacially separated comms sources
Audio - Display - Types	Ear Cup	integrated into ear cover of shell protection
Audio - Protection - Active or Passive	Active	active protection with transparent hearing (microphones on helmet exterior)
Audio - Protection - Types	Ear Cup	
Audio - Voice Input - Types	Beam Formed	microphone array situated in helmet brim
Sensor - Visual - Singular or Multiple Sensors	Multiple	two sensors
Sensor - Visual - Fixed or Interchangable Sensors	Interchangable	interchangable for day video, I2, or IR cameras, fusion options for I2/IR and day/IR
Sensor - Visual - Position - Optimized or Accommodative	Accommodative	ganged at one ear at the eyeline
Sensor - Audio - Array or Singular Mics	Array	array provides spacially accurate transparent hearing
Sensor - Radio Antenna - Integrated or off-helmet	Off-helmet	
Sensor - Laser - Array or Single Detector	Array	array provides directionality to source, sensors relate to head position and estimate source grid reference
Power and Data		
Physiological Sensors		sensors monitor critical physiological variables (HR, O2 saturation, EEG)

CONCEPT 4	Focus	Concept
	Survivability (CB) Mobility	This concept focuses on a CB protective helmet that emphasizes high mobility operations. (i.e. light, low forces on the head, low breathing resistance, less heat build-up)
Design Options:	**Selection**	**Comments**
Protection - Ballistic or Blast	Ballistic	
Ballistic - One-Piece or Add-on Layers	One piece	
Ballistic - Coverage - Low or Medium or High	low	mid-ear line
Ballistic Eyewear - Retractable or Add-on	add-on	
Ballistic Visor - Retractable or Add-on	snap on	
Mandibular Guard	No	
Impact - Fixed or Removable Components	fixed	impact liner with integral airflow channeling
Suspension - Leather or Mesh or Contact Pads	mesh	mesh suspension to maximize air circulation at head
Retention	four point	chin cup
CB Protection - Fully Integrated or Components	fully integrated	face piece mask which mates to balaclava seal (forehead, around face, under lips),
		rachet strap system used to pull mask into face, rachet knob at back of helmet with safety lock-outs
CB Protection - Positive or Negative Pressure	positive pressure	blower system on the torso, hose feed into back of helmet to provide cooling air, better protection, and less weight on head,
		airflow channels travel from front of helmet and converge at hose opening, face piece mask seals in front of channel outlets
CB Protection - Single or Double Canister	double cannister	hot swapable cannisters on torso blower, service life indicator built into audio display, no cannisters on mask
		low power option = attach a cannister at back of helmet (in hose opening)
Modularity - Low or Medium or High	medium	
Head Cooling - Active or Passive	mixed	passive airflow through channels in non-CB, powered blower in CB state
Anti-Fogging - Active or Passive	mixed	passive in non-CB, active in CB
Visual Display - Integrated or Component	component	
Visual Display - Types	microprism	
Visual Display Positioning - Retractable or Snap-on	snap on	retract into hangar, outside of mask, dashboard in non-CB, look-up in CB
Audio - High, Medium, or Component Integration	component	
Audio - Display - Monaural or Binaural or 2D Horizontal	binaural	
Audio - Display - Types	bone	
Audio - Protection - Active or Passive	passive	
Audio - Protection - Types	plugs or in-ear	
Audio - Voice Input - Types	Gel/bone	crown placement
Sensor - Visual - Singular or Multiple Sensors	singular	
Sensor - Visual - Fixed or Interchangable Sensors	interchangeable	interchangable for day video, I2, or IR cameras
Sensor - Visual - Position - Optimized or Accommodative	accommodative	
Sensor - Audio - Array or Singular Mics	singular	single gel mic
Sensor - Radio Antenna - Integrated or off-helmet	conformal antennae	applied to surface of the helmet
Sensor - Laser - Array or Single Detector	single	
Power and Data		

CONCEPT 5	Focus	Concept
	Survivability (CB) Survivability (ball.)	This concept focuses on a highly protective CB and Ballistic helmet.
Design Options:	**Selection**	**Comments**
Protection - Ballistic or Blast	Ballistic	
Ballistic - One-Piece or Add-on Layers	one piece	
Ballistic - Coverage - Low or Medium or High	High	
Ballistic Eyewear - Retractable or Add-on	retractable	eyewear retracts into brow of shell
Ballistic Visor - Retractable or Add-on	deployable	rotates into place, pulls in to rubber gasket to seal,
Mandibular Guard	Yes	mandibular guard is removable for non-CB use, service life indicator LEDs are mounted in the mandibular dashboard
		mandible is secured to helmet and oronasal cup is pushed into face to seal using rachet screw
Impact - Fixed or Removable Components	Fixed	crushable liner with 3D weave layer above comfort layer to distribute airflow
Suspension - Leather or Mesh or Contact Pads	webbing and leather	webbing/leather suspension is used to create good backface deformation standoff
Retention	four point	chincup
CB Protection - Fully Integrated or Components	fully integrated	mandible includes attachment for cannisters and oronasal cup, includes rubber seal to securing visor,
		deployable ring is pulled down from base of helmet to connect to dickie with mating ring at CB-Plus torso
		semi-permeable nano-compostie materials (e.g. poly-vinyl alcohol) suspended on skeletal framework
CB Protection - Positive or Negative Pressure	positive pressure	fan at back of helmet, visor is deployable off the face and pulls into the helmet and mandible seal when seated
CB Protection - Single or Double Canister	double	cannisters employ monolithic carbon tubes technology, cannisters are mounted up into mandible for connection to oronasal cup
		double scrub - outside air for face and 2nd scrub of helmet air through oronasal cannisters (longer duration or lower volume)
Modularity - Low or Medium or High	medium	
Head Cooling - Active or Passive	active	
Anti-Fogging - Active or Passive	active	
Visual Display - Integrated or Component	integrated	complete lens of eyewear = display area (i.e. much larger than typical LOE), display provided to both eyes
Visual Display - Types	LOE	
Visual Display Positioning - Retractable or Snap-on	retractable	retracts with the eyewear
Audio - High, Medium, or Component Integration	high	
Audio - Display - Monaural or Binaural or 2D Horizontal	3D	fully spacialized sound field, 3D localized sound sources, spacially separated comms sources
Audio - Display - Types	ear cup	integrated into ear cover of shell protection
Audio - Protection - Active or Passive	active	active protection with transparent hearing (microphones on helmet exterior)
Audio - Protection - Types	ear cup	
Audio - Voice Input - Types	beam formed	array is built into brim of helmet
Sensor - Visual - Singular or Multiple Sensors	single	
Sensor - Visual - Fixed or Interchangable Sensors	interchangeable	
Sensor - Visual - Position - Optimized or Accommodative	accommodative	
Sensor - Audio - Array or Singular Mics	array	
Sensor - Radio Antenna - Integrated or off-helmet	conformal	
Sensor - Laser - Array or Single Detector	six sensors	circumferential around head to enable computer system to determine direction of source
Power and Data		

CONCEPT 6	Focus	Concept
	C4I Sensors Survivability (high vel.)	This concept focuses on an optimized surveillance and information display helmet. High velocity ballistic up-armour option. (i.e. for use in surveillance, reconnaissance, and OP missions)
Design Options:	**Selection**	**Comments**
Protection - Ballistic or Blast	Ballistic	
Ballistic - One-Piece or Add-on Layers	Add-on	one-piece shell design with a high velocity threat protection cap for use in high risk surveillance, recce, OP tasks
Ballistic - Coverage - Low or Medium or High	High	
Ballistic Eyewear - Retractable or Add-on	retractable	
Ballistic Visor - Retractable or Add-on	Add-on	
Mandibular Guard	Yes	mandibular guard attaches under helmet and encloses entire helmet base
Impact - Fixed or Removable Components	Fixed	
Suspension - Leather or Mesh or Contact Pads	Contact pads	
Retention	four point	twin blade chincup
CB Protection - Fully Integrated or Components	Fully Integrated	mandible includes attachment for cannisters and oronasal cup, includes rubber seal to securing visor,
		deployable ring is pulled down from base of helmet to deploy tensioned neck gaiter down over dickie from CB-Plus torso
CB Protection - Positive or Negative Pressure	Positive	reversible positive pressure fan at back of helmet connects to mandible ring
CB Protection - Single or Double Canister	Double	two cannisters are attached to the mandible ring at the back sides of the helmet, cannisters can feed positive pressure and oronasal
Modularity - Low or Medium or High	Medium	
Head Cooling - Active or Passive	Active	In non-CB reversible fan pull airflow through helmet
Anti-Fogging - Active or Passive	Active	
Visual Display - Integrated or Component	integrated	integrated into eyewear
Visual Display - Types	Biocular LOEs	horizontal orientation for both LOEs
Visual Display Positioning - Retractable or Snap-on	retractable	retracts with the eyewear
Audio - High, Medium, or Component Integration	High	
Audio - Display - Monaural or Binaural or 2D Horizontal	3D	fully spacialized sound field, 3D localized sound sources, spacially separated comms sources
Audio - Display - Types	ear cup	integrated into ear cover of shell protection
Audio - Protection - Active or Passive	active	active protection with transparent hearing (microphones on helmet exterior)
Audio - Protection - Types	ear cup	
Audio - Voice Input - Types	beam formed	array is built into brim of helmet
Sensor - Visual - Singular or Multiple Sensors	multiple	all three sensors ganged on forehead area, including white light and IR illuminator
Sensor - Visual - Fixed or Interchangable Sensors	fixed	fixed, array of micro-cameras to record surrounding terrain for chameleon camouflage
Sensor - Visual - Position - Optimized or Accommodative	optimized	optimized sensor locations at visual saggital midline
Sensor - Audio - Array or Singular Mics	array	3D, supranormal hearing, highly directional localization, helmet can monitor audio targets and locations
Sensor - Radio Antenna - Integrated or off-helmet	off-helmet	GPS antenna requires clearance in the high velocity cap (maybe dielectric material would not affect GPS signal)
Sensor - Laser - Array or Single Detector	array	six sensors for directional determination
Power and Data		
Camouflage	Active	chameleon active camouflage
Illumination Devices	IR and white light	mounted high on the forehead area of the shell

CONCEPT 7	Focus	Concept
	Sustainability Mobility	This concept focuses on prolonged wear, physical and thermal comfort, low power consumption and limited resupply. (i.e. for use in unsupported missions e.g. long range patrol)
Design Options:	**Selection**	**Comments**
Protection - Ballistic or Blast	Ballistic	
Ballistic - One-Piece or Add-on Layers	add-on	two layers, second layer interlocking, overlapping armour tiles, includes solar collector covering on tiles or on helmet cover
Ballistic - Coverage - Low or Medium or High	low	high at the nape for prone observation and fire, ballistic shroud at neck (soft armour)
Ballistic Eyewear - Retractable or Add-on	add-on	ballistic eyewear
Ballistic Visor - Retractable or Add-on	snap-on	half-face visor
Mandibular Guard	No	
Impact - Fixed or Removable Components	fixed	coolmax next to skin, hypercell comfort layer, high impact attenuating material, user specific or custom moulded fit
		coolmax layer can be removed and washed, impact materials are perforated for convection of heat and sweat vapour
Suspension - Leather or Mesh or Contact Pads	see above	same as above
Retention	twin blade cup	four point retention
CB Protection - Fully Integrated or Components	components	separate mask and balaclava hood
CB Protection - Positive or Negative Pressure	negative	negative pressure mask
CB Protection - Single or Double Canister	single	single, low profile, low volume (2-3hrs) cannister, family of cannisters to suit longer durations and threats, service life indicator
Modularity - Low or Medium or High	high	only mission essential componentry
Head Cooling - Active or Passive	Passive	vents in brim provide passive airflow through channeling in impact liner to ridge vented shell,
		perforated comfort layer is aligned with perforated impact liner openings
Anti-Fogging - Active or Passive	Passive	anti-fog coatings
Visual Display - Integrated or Component	Component	snap on component, may need a hangar location on shell to stow when not in use
Visual Display - Types	Micro-Prism	small, light, robust
Visual Display Positioning - Retractable or Snap-on	Snap-on	snap-on but can articulate for positioning and stowage
Audio - High, Medium, or Component Integration	components	
Audio - Display - Monaural or Binaural or 2D Horizontal	binaural	
Audio - Display - Types	bone conduction	mounted under helmet to contact the zygomatic arch forward of the tragion
Audio - Protection - Active or Passive	passive	
Audio - Protection - Types	plugs	
Audio - Voice Input - Types	beam formed	
Sensor - Visual - Singular or Multiple Sensors	single	
Sensor - Visual - Fixed or Interchangable Sensors	interchangeable	interchangable for day video, I2, or IR cameras
Sensor - Visual - Position - Optimized or Accommodative	accommodative	locate beside ear at eyeline
Sensor - Audio - Array or Singular Mics	none	
Sensor - Radio Antenna - Integrated or off-helmet	off-helmet	
Sensor - Laser - Array or Single Detector	single	
Power and Data		
Physiological sensors		sustainment focussed sensors

Annex C: Original Seven Concepts—CB Features

	Concepts						
CB DESIGN OPTIONS	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Mask Options:							
Mask with head straps							
Mask/oronasal cup/mono lens							
Mandible with lens and oronasal							
Deployable visor and mandible							
Mask Securement:							
Head straps over hood							
Buckle or Mesh Flap Compression							
Ratchet Pull System (back)							
Ratchet Push System (front)							
Positive/Negative Pressure:							
Negative				**Low power**			
Positive w fan in helmet							
Positive w fan on torso							
Canister Locations:							
Mask canister(s)							
Nape canister(s)				**2nd**			
Double-scrub / nape and mask							
Torso-mounted canister(s)							
Canister Types:							
Low profile/low volume							
Stackable							
Monolithic carbon							
Canister Features:							
Service Life Indicator							
Hot-swappable							

	Concepts						
CB DESIGN OPTIONS	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Head/Neck Protection:							
Balaclava hood							
Balaclava hood w face seal							
Pull-down neck sleeve							
Neck Seal Options:							
Hood from torso							
Neck ring attachment							
Neck skirt							

Annex D: Four Downselected Concepts

CONCEPT A	Focus	Concept
	Mobility Lethality	This concept focuses on a high mobility helmet that can be mission configured for functionality and protection. (e.g. an urban assault helmet that can be up-armoured for different threats).
Design Options:	**Selection**	**Comments**
Shell	Scalable	0 layer = no shell, all functional componentry integrated into eyewear/head band
		1st layer = hard, light, thin shell, some penetration/fragmentation protection, bump protection,
		add-on to 1st layer = detachable ear guards to increase protection coverage to mid-ear line, guards would also offer
		attachment mechanism for other items or devices
		2nd layer = higher fragmentation threats, soft armour with resilient offset lattice
Coverage	Low	low mass, low profile, coverage no lower than mid-earline, 2nd layer close fitting, 3rd layer more standoff
Liner	Removable	1st layer = comfort pads next-to-skin, low profile 3D weave material, and thin or no layer of recoverable material,
		2nd layer = deformable lattice/soft armour deflection
Suspension	Contact pads	combined comfort/impact layer
Retention	Chinstrap	four point harness with twin blade chinstrap
Eyewear	Add-on	ballistic eyewear
Visor	Snap-on	half-face visor, snap on with the addition of second layer fragmentation protection
Mandibular Guard	Yes	mandibular guard is removable and attaches to add-on ear guards, guard is a grill over mouth to reduce fogging effects
CB Protection	Components	negative pressure mask with balaclava hood under helmet, hood material using semi-permeable technology
		mask seals over balaclava opening at face by crushing fabric material.
Cannisters	Single	single, low profile, low volume (2-3hrs) cannister, family of cannisters to suit longer durations and threats, service life indicator
Modularity	High	Wearers can configure their helmet with only mission essential componentry
Head Cooling	Passive	air flow channeling the length of the helmet, 3D weave materials form channels.
Anti-Fogging	Passive	anti-fog coatings
Visual Display	Micro-Prism	snap on component, light, small, robust, hangar location in shell to stow when not in use
Audio Display	In-ear	NACRE style, integration in device itself, binaural, ANR, high impulse filter, passive ear plug, active pass-through for ambient
		Transparent hearing would have two gain settings (normal for non-CB mode and high gain when wearing CB hood).
Speech Input	In-ear	microphone embedded in In-ear device
Sensor - Visual	Single	Two options will be investigated: one with interchangable cameras and another with a single fibre optic collector
		1st = single interchangable for day video, I2, or IR cameras, located beside ear at eyeline
		2nd = single fibre optic collector that can be used as the feed for any number of sensor processors (visual, I2, or IR), the
		fibre optic lens, with zoom capability, could be located between the eyes at the brow line using appropriate prisms.
Sensor - Radio Antenna	off-helmet	
Sensor - Laser	Single	single detector
Power and Data		integrated into 1st layer under hard shell

CONCEPT B	**Focus**	**Concept**
	C4I Survivability (CB)	This concept focuses on a helmet with greater display and sensor capabilities, and greater CB integration.
Design Options:	**Selection**	**Comments**
Shell	Ballistic Single Layer	includes add-on ballistic shroud for nape coverage
Coverage	Medium	coverage extends down to mid-ear level
Liner	Fixed	impact liner with integral airflow channeling
Suspension	Contact Pads	contact pads mounted onto impact liner layer
Retention	Chinstrap	four point harness with twin blade chinstrap, in CB state the mask will include a chin cup to secure the helmet
Helmet Cover		Solar collection weave material
Eyewear	Addon	ballistic eyewear
Visor	Retractable	snap-on, retractable half-face visor, retracts over outside of helmet
CB Protection	Components	combined mask/oronasal cup with mono lens, pulled into face with rachet straps
		balaclava hood (semi-permeable, thin, flexible) provides cutaneous protection and connection to CB Plus torso, compressed by mask
		Face cooling and demisting is achieved by integral fan in mask. Fan samples from inhalation valve at low volume and
		circulated air over the mono-lens, the air is then pulled into the oro-nasal mask during inhalation, and vented across the
		exhalation valve for added protection
Cannisters	Double	cannisters employ monolithic carbon tubes technology, double cannisters are mounted to mask
Modularity	Medium	
Head Cooling	Active	fan at back of helmet pulls air through helmet (front to back), draws air through channels in the impact liner layer, a low power fan
		draws air flow through channeling the length of the helmet, channelling is moulded into the impact liner layer.
Anti-Fogging	Active	fan powered airflow washes over eyewear
Visual Display	LOE/VRD	see-through, augmented reality displays integrated into the shell structure of the helmet retractable into brow of helmet,
Audio Display	Bone Conduction	Integrated into comfort layer, protection provided by passive plugs, transparent hearing provided by external array
		mounted under helmet to contact the zygomatic arch forward of the tragion
Speech Input	Bone Conduction	
Sensor - Visual	Multiple	two sensors interchangable for day video, I2, or IR cameras, fusion options for I2/IR and day/IR, ganged at one ear at the eyeline
Sensor - Audio	Array	array provides spacially accurate transparent hearing
Sensor - Radio Antenna	Off-helmet	
Sensor - Laser	Array	array provides directionality to source, sensors relate to head position and estimate source grid reference
Power and Data		integrated into hard shell
Physiological Sensors		sensors monitor critical physiological variables (e.g. HR, O2 saturation, EEG

CONCEPT C	Focus	Concept
	C4I Sensors Survivability (high vel.)	This concept focuses on an optimized surveillance and information display helmet. High velocity ballistic up-armour option. (i.e. for use in surveillance, reconnaissance, and OP missions)
Design Options:	**Selection**	**Comments**
Shell	Two Layer	one-piece shell design with a higher threat protection cap for use in high risk surveillance, recce, OP tasks
Coverage	High	coverage extends down to cover ears and parts of the neck and jaw
Liner	Fixed	high impact attenuating material, user specific or custom moulded fit, materials are perforated for convection of heat and sweat vapour
Suspension	Contact pads	coolmax next to skin, hypercell comfort layer, coolmax layer can be removed and washed
Retention	four point	twin blade chinstrap with four point harness
Eyewear	Add-on	eyewear are removable
Visor	Add-on	
Mandibular Guard	Partial	partial mandibular guards include detachable impact absorbing pads to improve protection during higher threats
CB Protection	Fully Integrated	face piece mask which mates to rubber balaclava seal (forehead, around face, under lips) on hood,
		rachet strap system used to pull mask into face, rachet knob at back of helmet with safety lock-outs
	positive pressure	blower system on the torso, hose feed into back of helmet to provide cooling air, better protection, and less weight on head,
		airflow channels travel from front of helmet and converge at hose opening for head cooling (separate to mask)
		Separate hose connects to cannister connector at cheek of mask through a valve connector at the back of the jaw line
		The filtered air circulates through ducts in the mask to cool the face and demist the visor, air is then drawn into oronasal cup
		through valves to be inhaled and then exhaled directly from the oro-nasal mask.
Cannisters	double cannister	hot swapable cannisters on torso blower, service life indicator built into audio display, no cannisters on mask
		low power option = attach a cannister at the cheek connector of the mask
Modularity	Medium	
Head Cooling	mixed	passive airflow through channels in non-CB, powered blower in CB state
Anti-Fogging	mixed	passive in non-CB, active in CB state
Visual Display	Biocular Microprisms	biocular microprism displays that retract and deploy hands-free from hangar locations in the brim
Audio - Display	Ear Cup	highly integrated into ear cover of shell, 3D audio sound field and sources, active protection with transparent hearing, ear cup protection
Speech Input	beam formed	array is built into brim of helmet
Sensor - Visual	multiple	single optical zoom lens located centrally above brim or at one side of the helmet
		single image is collected by coherent fiber optic bundle that distributes image pixels to multiple sensor collectors (day, I2 and IR) off head
Sensor - Audio	array	3D array that can provide supranormal hearing, highly directional localization, helmet can monitor audio targets and locations
Sensor - Radio Antenna	off-helmet	GPS antenna requires clearance in the high velocity cap (maybe dielectric material would not affect GPS signal)
Sensor - Laser	array	six sensors for directional determination
Power and Data		integrated below 1st shell layer
Illumination Devices	IR and white light	mounted high on the forehead area of the shell
Physiological sensors		sustainment focussed sensors

CONCEPT D	Focus	Concept
	Survivability (CB) Survivability (ball.)	This concept focuses on a highly protective CB and Ballistic helmet.
Design Options:	**Selection**	**Comments**
Shell	Single Layer	
Coverage	High	
Liner	Fixed	crushable liner material
Suspension	webbing and leather	webbing/leather suspension to create good backface deformation standoff and airflow circulation
Retention	four point	chincup and four point harness
Eyewear	none	no eyewear is intended for this system
Visor	permanent/exchangeable	the half-faced visor is affixed to the helmet, includes add-on shields for solar, laser, low-light filters
Mandibular Guard	Yes (CB only)	mandibular guard comprises a complete ring that attaches to the bottom of the helmet (i.e. a lower half of the helmet).
		Removable for non-CB use,
		mandible includes an oronasal cup that can be pushed into the face using a rachet screw, in MOPP 2 cup can be pulled back from face.
CB Protection	fully integrated	Helmet is sealed at the neck and filtered air is provided to the helmet for breathing, cooling, and demisting via a hose from the torso-
	enclosed system	mounted cannister/blower system.
		mandible includes a rubber seal well to mate with and secure to the visor, or visor is permanently attached to mandible
	positive pressure	Airflow cools head and face, and demists visor, air is then drawn into oronasal cup through valves and then exhausted directly.
Neck Seal		Deployable ring is pulled down from base of helmet to deploy neck skirt over dickie from CB-Plus torso
		neck skirt includes rubber neck seal inner and semi-permeable nano-composite materials (e.g. poly-vinyl alcohol) outer cover
Cannisters	double	shallow, low profile design. Cannister layers are stackable to increase duration or adapt to threat mix, audio service life indicator
Modularity	medium	
Head Cooling	active	
Anti-Fogging	active	
Visual Display	VRD	Retractable virtual retinal lens deploys from brim section of helmet
Audio - Display	Ear Cup	highly integrated into ear cover of shell, 3D audio sound field and sources, active protection with transparent hearing, ear cup protection
Speech Input	beam formed	array is built into sides of helmet
Sensor - Visual	Single	single or double optical zoom lense located near the ear at the eyeline,
		single image is collected by coherent fiber optic bundle that distributes image pixels to single sensor collectors (day, I2 and IR) off head
Sensor - Audio	array	
Sensor - Radio Antenna	conformal	
Sensor - Laser	six sensors	circumferential around head to enable computer system to determine direction of source
Power and Data		integrated below shell

Annex E: Traceability Tables

Incorporation of Features from Original Designs into New Concepts

	Features considered	New Concepts	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5	Concept 6	Concept 7
Head/Shell	Scalable	A,C	■	■				■	■
	Ballistic Single Layer	B,D			■	■	■		
	No shell	A							
	Independent C4I headband	A							
	Ballistic Shroud	B							■
	Low Coverage	A	■	■		■			■
	Medium Coverage	B							
	High Coverage	C,D			■		■	■	
	Add-on Ballistic Eyewear	A,B	■	■	■	■			■
	Retractable Ballistic Eyewear	C,D					■	■	
	Snap-On Visor	A,C	■	■		■		■	■
	Retractable Visor	B,D			■		■		
	Mandibular Guard	A,D		■			■	■	
	Partial Mandibular Guard	C							
	Removable Earguards	A							
	Facial Impact Protection	C							
	Fixed Impact Components	B,D		■	■	■	■	■	■
	Removable Impact Components	A	■						
	Moulded Impact Liner	C							■
	Leather and Webbing Suspension	D					■		
	MESH SUSPENSION					■			
	Contact Pad Suspension	A,B,C	■	■	■			■	
	Chin Cup	B (in CB), D				■	■		
	Twin-blade Strap	A,B,C	■	■	■			■	■
	Helmet Cover	B							■
	RIDGE VENT								
Modularity	Medium Modularity	B,C,D			■	■	■	■	
	High Modularity	A	■	■					■

Incorporation of Features from Original Designs into New Concepts (Cont.)

Respiratory	Components (Mask and Hood)	A,B	■	■	■				■
	Fully Integrated	C,D				■	■	■	
	Single Canister	A	■	■					■
	Double Canister	B,C,D			■	■	■	■	
	DOUBLE SCRUB				■		■		
	Ratchet Strap Attachment System	B							
	Carbon powder canister	A,B,C							
	Monolithic carbon canister	B					■		
	Neck skirt/ seal	D						■	
	NECK RING						■		
	Power (active cooling and anti-fogging)	B,D			■		■	■	
	No-power (passive cooling and anti-fogging)	A	■	■					■
	Mixed cooling and anti-fogging	C				■			
	Negative pressure mask	A,B				■			
	Positive pressure mask	C,D							
Visual Displays	Monocular micro-prism	A	■	■		■			■
	Monocular VRD	B,D			■				
	Monocular LOE	B		■	■		■		
	Biocular micro-prism or LOE	C						■	
Visual Sensors	Single	A,D	■	■		■	■		■
	Multiple	B,C			■			■	
	Processor on-helmet with cabling	B	■	■	■	■	■	■	■
	Fibre optic pathway to processor off-head	A,C,D							
Audio Display	Bone Conduction	B				■			■
	In-ear (NACRE)	A	■	■					
	Ear Cup	C,D			■		■	■	
Audio Voice Input	In-ear	A	■	■					
	Bone Microphone	B				■			
	Beam-formed	C,D			■		■	■	■
Hearing Protection	In-Ear	A,B	■	■		■			■
	Ear-Cup	C,D			■		■	■	

Incorporation of Features from Original Designs into New Concepts (Cont.)

Other Sensors	Audio Single Microphone	A	■			■			
	Audio Array Microphones	B,C,D			■		■	■	
	Conformal Radio Antenna	D				■	■		
	Off-helmet Radio Antenna	A,B,C	■	■	■			■	■
	Single Laser Sensor	A	■	■		■			■
	Laser Sensor Array	B,C,D			■		■	■	
	IR and white light Illumination Devices	C		■				■	
	Physiological Sensors	B,C			■				■

Features Incorporated into New Designs

	Features considered	Concept A	Concept B	Concept C	Concept D
Head/Shell	Scalable	■		■	
	Ballistic Single Layer		■		■
	No shell	■			
	Independent C4I headband	■			
	Ballistic Shroud		■		
	Low Coverage	■			
	Medium Coverage		■		
	High Coverage			■	■
	Add-on Ballistic Eyewear	■	■		
	Retractable Ballistic Eyewear			■	■
	Snap-On Visor	■		■	
	Retractable Visor		■		■
	Mandibular Guard	■			■
	Partial Mandibular Guard			■	
	Removable Earguards	■			
	Facial Impact Protection			■	
	Fixed Impact Components		■		■
	Removable Impact Components	■			
	Moulded Impact Liner			■	
	Leather and Webbing Suspension				■
	MESH SUSPENSION				
	Contact Pad Suspension	■	■	■	
	Chin Cup		■ CB Only		■
	Twin-blade Strap	■	■	■	
	Helmet Cover		■		
	RIDGE VENT				
Modularity	Medium Modularity		■	■	■
	High Modularity	■			
Respiratory	Components (Mask and Hood)	■	■		
	Fully Integrated			■	■
	Single Canister	■			
	Double Canister		■	■	■
	DOUBLE SCRUB				
	Ratchet Strap Attachment System		■		
	Carbon powder canister	■	■	■	
	Monolithic carbon canister		■		
	Neck skirt/ seal				■
	NECK RING				
	Power (active cooling and anti-fogging)		■		■
	No-power (passive cooling and anti-fogging)	■			
	Mixed cooling and anti-fogging			■	
	Negative pressure mask	■	■		
	Positive pressure mask			■	■

Features Incorporated into New Designs (Cont.)

Visual Displays	Monocular micro-prism	■			
	Monocular VRD		■		■
	Monocular LOE		■		
	Biocular micro-prism or LOE			■	
Visual Sensors	Single	■			■
	Multiple		■	■	
	Processor on-helmet with cabling		■		
	Fibre optic pathway to processor off-head	■		■	■
Audio Display	Bone Conduction		■		
	In-ear (NACRE)	■			
	Ear Cup			■	■
Audio Voice Input	In-ear	■			
	Bone Mic		■		
	Beam-formed			■	■
Hearing Protection	In-Ear	■	■		
	Ear-Cup			■	■
Other Sensors	Audio Single Microphone	■			
	Audio Array Microphones		■	■	■
	Conformal Radio Antenna				■
	Off-helmet Radio Antenna	■	■	■	
	Single Laser Sensor	■			
	Laser Sensor Array		■	■	■
	IR and white light Illumination Devices			■	
	Physiological Sensors		■	■	

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(U) The aim of the Soldier's Integrated Headwear System (SIHS) project is to empirically determine the most promising headwear integration concept that significantly enhances the survivability and effectiveness of the future Canadian soldier/warfighter by developing, evaluating, and demonstrating novel concepts for integrating enhanced protection, sensing, information display, and communications technologies into a headwear system. The SIHS design cycle comprises four developmental phases: concept design, digital models, physical mock−ups, and a final functional prototype. This report describes the process and results of the concept development phase.

Seven concept helmet designs were developed using conceptual foci based on helmet and operational functions, and helmet capabilities in relation to the five NATO capability areas: lethality, survivability, mobility, sustainability, and C4I. A downselection process was then undertaken to progress the most successful features and capabilities of the seven concepts into four new concepts for further development in the Digital Model Development phase. The traceability of all design ideas, from the initial seven concepts through to the four new downselected concepts, is detailed in this report.

(U) Le but du projet de Casque intégré du soldat (SIHS) est de déterminer empiriquement quel concept de casque intégré est le plus susceptible d'améliorer la capacité de survie et l'efficacité du soldat/combattant canadien de demain, grâce au développement, à l'évaluation et à la mise à l'essai de nouveaux casques qui intègrent une protection accrue, des capteurs, un système d'affichage des informations et des systèmes de communication. Le cycle de développement du SIHS comprend quatre phases : élaboration de concepts, développement de modèles numériques, production d'une maquette, et production d'un prototype fonctionnel. Le rapport décrit le processus de développement et les résultats de la phase d'élaboration de concepts.

Sept concepts de casque intégré ont été développés en mettant l'accent sur le casque et ses fonctions opérationnelles, et sur la performance par rapport aux cinq domaines de capacité de l'OTAN : létalité, survivabilité, mobilité, soutenabilité et C4I. Un processus de sélection des meilleures idées a ensuite été entrepris pour ramener de sept à quatre le nombre de concepts retenus pour la phase de développement de modèles numériques. Tous les nouveaux concepts, depuis les sept concepts initiaux jusqu'aux quatre concepts sélectionnés, sont décrits dans le rapport.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

(U) SIHS; Soldier Integrated Headwear System; concept design; digital models; helmet; lethality; survivability; mobility; sustainability; C4I; enhanced protection; sensing; information display; headwear system